FEBRUARY 10, 1981

Hydrology

1110 Groundwater
AM APPRIACH TO DETERMINING PATHWAYS AND RESIDENCE
THREOF CHOCHOMATERS: LUAL RADIOTRACES DATING
S. S. Gaple, D. Lei and P. Tharma (Physical 3. f. Capta. D. Lal and F. Tharms (Physical Lascatch Laboratory, Almedabad 190009, India) in a highly dispersive groundwiner flow mystem (Dia >1), application of plane flow model leads to createrable oversationation of flow velocity. In the case of seal-confined auditors the flow velocity is further oversationated due to addition of relatively young water through leakage from crariying shallow equifers. In this paper we discuss how taxing on almaltaneous measurements of two modelaters of widely differing half lives, one can obtain meaningful attinates of discuss how raning on minultaneous measurements of two radiotraners of videly differing ball lives, one can obtain quantingful estimates of the audiest persenters, namely the flow velocity, dispersion coefficient and the lankance. We have studied the behaviour of a radiotracer using the diffusion-advention equation for the atacky state groundwater movement through porous sedia and malysed the propagation of the radiotracer along the direction of flow in the squifer for time swining due to non-radioactive loss of radiotracers are discussed in attail. The arrors in the estimation of the man dispersion size (D/u²) arising from () finalte errors in the measurement of radiotracer concentrations and (ii) limits non-radioactive loss of the tracers in the squifer have been evaluated. These calculations allow one to select a suitable "pair" of radiotracers for a given field allustion.

It is transcripted to the second product of Water Pesser. Res., Paper BDW1616

3130 Ground Water AMALYSIS OF THE RECIPROCITY CONCEPT IN POROUS

MEDIUM.

6. K. Falade (Department of Petroleum Enginearing University of Badan, MiGERIA)

The general Reciprocity Relation was proved to be valid for flow of fiold through porous medium. The validity was demanstrated for flow within a semi-infinite domain and also for a finite domain bounded by inpermeable boundaries. A graphical analysis of the Reciprocity Relation was presented for the bounded system. Water Resour, Ros., Paper SON1807

3150 Precipitation THE RAINSTORM WHICH CAUSED THE MORVI DAM DISASTER

NSO Freeightation
SIR RAINSTORM WHICH CAUSED THE MORNY DAN DISASTER
IN AUGUST 1979
O.M. Dear (Indian Institute of Tyopical
Rateorology, Foone-5, India; F.R. Rakbechs, B.B.
Mandal and R.B. Eangam
On 11 August 1979, the Machbu-2 earth dam,
situated about 6 hm upstream of the town of Morvi
in the Seurashta region of India, collapsed
under the onrush of an unprecedented volume of
water. An B-10 m high flood wave rolled down
Macons wallay, entirely submarging Morvi and
Learby villages. This flash flood caused the
deaths of thousands of people and totally
destroyed urban and rural property downstream of
the dam. The heavy reinfall of August 1979
over and around the Machbu beain has been
aralysed by toth depth-area-duration and daythduration methods. Important aspects of heavy
reinfall distribution such are analysis of pust
severe reinstorms, maxisum point rainfall of
different return periods, and probable maxisum
precipitation, were also studied. This study
has shown that this sevent was not the most
severe rainstorm in this region. Founibly,
the entocedent conditions of the Machhu basin
player a significant role in generating the flood
volume which caused the earth Flanks of the dam
to give way. (Rainstorm, dam break)
hydrological griences Bull. vol. 26, no. 1,

1160 Purpli and atreamilov A LEARY RESERVOIR MODEL FOR EPHEMERAL FLOW FECESSION E. Peebles(Citics of Surface Mining, Dept. of Interior, Markingtop, D.C., 20240) R.E. Smith and E.3. Vahouter

interior, Markington, D.C., 207409 R.E. Seath and S.J. Yakowitz
The flood wars in ophemeral streams can often be postrayed accurately by assuming "instantane-one" year peak flood steps (depth) and appelitying a rectablen curve. Berr reversion in modeled as a conceptual analog of discharge from a single leaky reservoir may be considered to approximate that portion of the sphemeral trees channel that is flowing at the onset of recession, the discharging reservoir is described by a continuity equation and by discharge-stage (stress rating) and abstance alog (enervoir configuration) and abstance and finguration and configuration and energy and energy and initial storage (reservoir abspect of accession the reservoir leakage rate and initial storage (reservoir abspect). The agreement is not associated to changes in initial storage, the best fit parameters, leave are physically plausible.

Mater Resour, Res., Paper 80M1741 Water Resour, Res., Paper BOH1741

SUNOFF and Streamflow EDICTION OF RIVER WATER TEMPERATURES

In LEG. UK)
Temperature is arguably the most significant single determinant of water quality but data are collected at comparatively few locations and era rearely subjected to systematic analysis. This paper details two different cathods suitable for vater managers engaged in predicting river temperatures on an operational basis over a wide resperatures on an operational basis over a wide resperatures on an operational for estimating annual and monthly river temperature to an acceptable level of accuracy using air temperatures at an amprical equation can be fitted to short term observations of river temperature in order to represent the characteristic sessional and diurnal cycles. (Prediction river water temperature) Hydrological Echences Bull. vol. 26, no. 1.

OFTHAL SEGRY-TEM HTMRO SCREDULING FROM THE PRINCIPLE OF PROGRESSIVE OPTIMALITY Andre Tempson (Hydro-Quahec, Varennes, Qua., Ganada JOL-2FO)

This paper presents an algorithm based on the principle of progressive optimality for determining the optimal short-term scheduling of multi-reservoir power systems; the mached takes into account water head variations, spilling, and time delays between upatream and downstream remervoir and delays between upatream and downstream remervoir method is computationally efficient and has minimal storage requirements. The convergence is the method is computationally efficient and has minimal storage requirements. The convergence is monotonic and a Slobal solution is reached. Contrary to dynamic programming, the state variables do not have to be discretized with this method. An example consisting of four hydroplants in series is solved and the results are presented.

3170 Snow and Ice
AUXOMATED SPETCH FOR COLLECTING SNOW AND RELATED
RYPROGODICAL DATA IN MOUTTAINS OF THE WESTERN
UNITED STATES
Robert E. Rallison (Engineering Division, Soil
Conservation Service, FO Sox 2890, Washington,
DC 20013)
Shawalt rumoff, primerily from mountains,
contributes about 75% of the water supply in the
wostern Whited States. Snow and velated
hydrological data have been collected from remote
mountain sites for more than ho years primarily
through annual methods. An automated data
collection system called SHOTEL (for snow
telementy) is being installed. A portion of
the system passed an operational test early in
1979, and installation of the entire system of
supproximately 500 sutcomated data sites is
superted to be complete by Sovember 1980.
Sensors to measure snow water content,
accumulated procipitation, and temperature are
standard at each SHOTEL site. The automated
sensors will sliminate the need for manual
measurements at more than 500 or the 1600 data
sites in the snow data network. The SHOTEL
commonication system uses more as 1000 remote sites
take from the system which operates in mater
real ting is empalse of collecting and transmitting data from as many as 16 digital or madog sensors
of the site, (Automated data collection snow)
Rydrological Sciences Spil, voi. 25, pc. 1.

Modern Geodetic Earth Reference Models

Bernard H. Chovitz

National Ocean Survey, NOAA

A geodetic earth reference model is defined as a selfgravitating body of given mass and rotational rate whose surface is an equipotential ellipsoid of revolution of specified dimensions. Over the course of this century, the international Association of Geodesy has sanctioned three such models as recommended standards for both scientific and practical applications. The most recent model was approved in December 1979, replacing one chosen in 1967, which in turn supplanted another originally adopted four decades earlier.

Introduction

One of the chief scientific aims of geodesy is the determination of the size and shape of the earth. Therefore, much of the energy expended by geodesists has focused on finding a model (defined by both geometrical and physical parameters) that can serve as a sultable reference surface for further geodetic and geophysical investigations. 'Suitable' is a flexible term. In the 19th century, it may have inferred accuracy to one part in 104. Nowadays, it signifies better than one part

Another equally important aim of geodesy is to provide a rigorous and precise basis for surveying and mapping. An internationally accepted reference model expedites cooperation between countries and serves as a secure foundation on which to support expensive and time-consuming projects. Toward this aim, permanence, or at least longevity, is as vital as accuracy.

The purpose of this article is to cover the development of recognized models for the figure of the earth during this century. The determinations of the earth's scale, by Eratosthenes in the 3rd century B.C., and of its flattening, by the Peru-Lapland expeditions in the 18th century, are well known to most scientists. But the remarkable improvements occurring in recent times are not generally appreciated outside of the narrow geodetic community.

By 'recognized models' we mean those that have received a measure of official approval by the International Association of Geodesy (IAG) and its covering organization, the International Union of Geodesy and Geophysics (IUGG). Thus this narrative, in large part, is a history of deliberations of the AG. Much of the interest centers on the reaction of the IAG to the conflicting requirements induced by the two aims men-

The Normal Ellipsoid

The prototype model for the figure of the earth is a biaxial ellipsold of revolution which is completely specified by two geometric parameters. Let a and b be the semimajor and semiminor axes of this model. The flattening f is defined by f = (a - b)/a. Customarily and conventionally, a and f are the two parameters designated. If geometric quantities, like arc measurements and relative station positions, are all with which one is concerned, then such a model is adequate. However, once physical properties are considered, a less simple approach must be taken. For the computation of gravity on the model, it is obvious that one has to introduce some information on the mass of the earth, that is, a third parameter. Furthermore, it is also obvious that this value of gravity is



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Cover Small Impact crater near Taal volcano. Crater is only 0.9m In diameter, and it shows the shock waves left by the impact of a bomb lossed out of the crater in the 1985 eruption. (Photo courtesy of Francis J. Heyden, Manila Observatory, The Philippines.)

influenced by the fact that the earth is rotating, indicating the need for a fourth parameter. But this suffices. Earth models are now usually defined by four parameters (plus a designation of the orientation of the axis of maximum inertia in inertial

Thus it can be inferred that a legitimate model, which should be able to handle both physical and geometric chores, might be an ellipsoid of revolution of mass \widetilde{M} , rotating at angular speed ω , and hence defined by a parameter family (a, f, M, ω). It is shown in standard texts [e.g., Heiskanen and Moritz, 1967, pp. 64-67) that if the constraint is imposed that the surface of the model be level (i.e., equipotential), then the exterior gravitational field generated by this configuration is unique (the so-called Somigliana field). Note that no assumption has been made about the distribution of mass within the model. This model is designated as a normal ellipsoid.

The accuracy of the model depends on how well the nu-

merical values of the parameters are chosen. In order to accord with reality, they should be based on the best observational data available: a has always been comparatively well determined from arcs of triangulation; ω depends on straightforward astronomical measurements; however, in two instances, M and f, the observational material is relatively weak. Fortunately, these particular parameters can be replaced by equivalent quantities that are much better determined. Consider the product GM, where G is the universal constant of gravitation. One need be familiar only with Newton's law of gravitation to realize that in dealing with any measurement involving the earth's gravity field (and thus bringing into play physical considerations), whenever M appears, it is in the guise of GM. Modern measurement techniques which employ artificial satellites and planetary probes have refined the value of GM to 1 part in 107, whereas M itself is known only to about 1 part in 103. Prior to the artificial satellite era, the best determined quantity relating to the earth's gravity field was surface gravity itself. It was thus customary to accept as a parameter in place of M the equatorial value of gravily y_e , whose unique relation to the other parameters is spelled out in Heiskanen and Moritz [1967, p. 69].

Historically, a variety of geometric and physical methods have been employed to determine f. A complete record can be found in the monograph by Strasser [1957]. However, up until 1957, when the first artificial Earth satellite was launched, accuracy was good only to hardly better than 1 part in 100. (Strasser's account goes through 1953.) Then, almost immediately, an equivalent parameter was determined from observations on artificial satellites to at least an order of magnitude better. This parameter, the dynamical form factor, designated by J_2 (because it is the coefficient of the second zonal harmonic ferm in the spherical harmonic expansion of the earth's exterior potential field), is directly related to f for a normal ellipsoid by a closed formula involving just the other independent parameters (Heiskanen and Moritz, 1967, p. 73]. Thus the modern definition of the normal ellipsoid is by means of the parameters a, Jz, GM, w.

We stress again that a particular normal ellipsoid generates a unique exterior gravitational field. This field can be specified by an infinite set of coefficients J, (i = 2, 4, 6, ...)that correspond to the even zonal harmonic terms in the spherical harmonic expansion of the earth's potential. However, all J_i for i > 2 are functions of the parameter set (a, J_a , GM, ω). It is interesting to consider the range of parameter sets that can simulate closely the actual gravitational field. For example, one can take the real value of J_2 but set $\omega = 0$. In that case, f would be about 1/700, less than half the real value. But although J_2 is enforced to be the same, the other J_1 will change, and thus the property of uniqueness is honored.

Because the potential is constant on the surface of the normai ellipsoid, its value U_0 (units: m^2s^{-2}) could replace a as one of the defining parameters. This has a certain appeal, since the set (U_0, J_2, GM, ω) relates directly to the physical situation (cf. also Builetin Géodésique, New Series 118, 1975, p. 402). However, U_0 suffers from the same observational deficiency as M; a is much more accurately measured.

Recapitulating, the modern accepted model for the figure of the earth is the normal ellipsoid, defined thus: (1) its geometric shape is that of an ellipsoid of revolution with semimajor axis a and flattening f. (2) The mass of the ellipsoid is M. (3) The ellipsoid rotates at angular speed ω. (4) The surface is level.

Under these assumptions the exterior gravitational field is completely determined, although the interior field is not. However, the choice of the four defining parameters constrains the possible distribution of mass within the model. For example, if the additional assumption were made that the modbe homogeneous. If we wish to retain an Earthlike density distribution along with conditions (2), (3), and (4), then (1) becomes distorted into a fourth-order surface that requires an additional parameter for complete delineation. For a more penetrating discussion of this topic, see Moritz [1968].

The International Ellipsoid

Specifications for a unified model (like the normal ellipsoid) that is suitable for both geometric and physical applications were not formulated until this century was well underway. However, the requisite theory had been available in Friedrich Helmen's monumental treatise [Helmen, 1880]. At the beginning of this century, there was much activity to determine geometric ellipsoids that would serve as reference figures for large triangulation systems and to set up standard gravity formulas that were derived from a simple mass configuration, from which gravity anomalies could be computed. Measured values of gravity itself served as a basis (and, according to Helmert, the best basis) for determining the geometric flattening, the link being through the classic (18th century) formula of Clairaut. The name of Heliment pervades all research in this field during this period. In 1901, he published a value for f, 1/298,3, which was based on gravity measurements. Five years later, he computed a to be 6,378,140 m, based on European arc measurements and the aforementloned value of i. The closeness of this set to presently accepted values is

almost uncanny. An element of luck is surely present here, because, upon adding more data, Helmert's values of a in a subsequent solution increased to 6,378,200 m.

Also, at the beginning of this century, a large effort was mounted at the U.S. Coast and Geodetic Survey, under the leadership of John Hayford, to determine a reference ellipsold by applying a principle heretofore untried for this purpose. The method employed by Helmert was to minimize (in the sense of least squares) the observed deviations of the actual Earth from an ellipsoid of revolution by treating these deviations as random. Hayford realized that the observations could be biased because of their poor distribution and refative paucity. He therefore applied the theory of isostasy as a corrective process to his observations, all in the U.S. A preliminary solution was announced by Hayford at the 1906 General Conference of the International Geodetic Association (the progenitor of the international Association of Geodesy), and a revised solution, based on additional data in the U.S., was presented at the next general conference, held in 1909. This last solution consisted of a = 6.378.388 m and f =1/297.0. The time was ripe for official international agreement on a standard model to which geodelic triangulation, now overrunning national boundaries, could be referred. World War I interrupted such considerations.

However, the question was raised at the constitutive assembly of the IUGG in Brussels in 1919, and was formally discussed at the first general assembly of the IUGG, held in Rome in 1922. At the meeting of the then-termed Section of Geodesy (the title of Association came into effect in 1932 and of International Association in 1946), William Bowle brought up the distinction between the scientific and the practical purposes for a choice. The former required the best (i.e., the most accurate) determination, whereas the latter simply demanded unanimity among the national geodetic organizations. A resolution passed by the assembly in Rome advocated (modestly) a common reference ellipsoid for all nations on the same continent. The next general assembly was held in Madrid in 1924. Just before the assembly convened, the executive committee of the Section of Geodesy agreed that the Rome resolution be modified to consider a single ellipsoid for all continents. A great deal of spirited discussion ensued during the general sessions. Although feeling was practically unanimous on the need for an international reference ellipsoid, the choice of parameters was controversial. In particular, the British delegation favored a rounded set of values (i.e., the semirmajor axis specified to only live significant figures). Because Hayford's value of / matched fairly closely (i.e., to within the stated standard errors) the result obtained from Helmert's gravity investigations, and because it gave the impression of being a rounded value (1/297.0), there was little opposition to it. On the other hand, the choice of a was bitterly contested. Hayford's result was criticized because it was based solely on measurements in the U.S. and because its seven significant figures were too many to be believable. Bowle defended the Hayford value by arguing that the application of the theory of Isostasy and the varying terrain in the U.S. sufficiently generalized the solution. Moreover, he was against rounding, because the exact result made it clear on what basis the values were chosen and to what the standard errors referred. Haylord's value of 6,378,388 m was narrowly approved by a vote of 19 to 17.

Thus, for the first time, a reference ellipsoid was officially recognized by the international geodetic community. It was termed the International ellipsoid. There are two interesting footnotes regarding this choice. First, although the geodesists waited until 1924 to take organized action, at a meeting of the International Congress of Astronomical Ephemerides, In Paris in 1911, the delegates gave an official astronomical imprimatur to 1/297.0, an anticipatory action that was repeated, vis-a-vis the geodesists, in later years. Second, although an American result was apotheosized internationally, the U.S. had no intention (and Bowle announced this in advance) of converting its own national triangulation system to the newly crowned reference model because it did not deem the

required effort as necessary or worthwhile. Soon after the choice of this set of geometric parameters, Lambert [1926] raised the question of the desirability of determining a formula for theoretical gravity that was compatible with the international ellipsoid as a level surface. Cassinis [1930] published the definitive formulas, based on the work of Pizzetti and Somigilana [Heiskanen and Moritz, 1967, p. 70], and proposed the numerical values

> $\omega = 0.7292115(10^{-4}) \text{ rad s}^{-1}$ $\gamma_e = 978.049 \,\text{Gal} \,(1 \,\text{Gal} = 10^{-2} \,\text{ms}^{-2})$

These, combined with the international ellipsoid values of a and f, formed the basis for defining the international gravity formula, adopted at the 4th General Assembly of the IUGG in Stockholm in 1930. A complete set of parameters for an internationally recognized normal ellipsoid had now been estab-

The Geodetic Reference System 1967

After this, the question of revision of these parameters lay dormant within the geodetic establishment for 30 years. This was not due to lack of scientific progress in improving their values. Hayford's semimajor axis was generally recognized to be too large. By omitting doubtful observational material,

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the Coast and Geodetic Survey's refinement of Hayford's computations indicated a decrease in a of about 150 m [Schmid, 1953]. Independent determinations by Krasovskiy in 1940 [Strasser, 1957, p. 74] and Chovitz and Fischer [1956], which used newly available long arcs, confirmed the elephantic size of the officially adopted value. However, two reasons lay behind a lack of interest in change. The first, held by the 'practical' geodesists, was that the purpose of the normal ellipsoid was to serve as a fixed reference. The deviation of the reference from reality was not crucial, but its meaningluiness as a reference would be dissipated if it were frequently altered. As one well-known geodesist exclaimed in a discussion on this subject during this period, 'A cube could serve the purpose adequately.' This point of view, satisfactory as it may have been to those in charge of preparing national geodetic networks and cartographical products, of fended 'aesthetic' geodesists. However, the latter were held back by the second reason, which was the wide discrepancy in accuracy of determination among the parameters. A revision in a, based on latest knowledge, would have reduced its error from 4 to 2 parts in 105. But there was not much point in attending to this while an error of almost 1 part in 102 remained in /.

As mentioned earlier, observations on artificial Earth satelfites, beginning in 1957, provided a breakthrough—indeed, the most spectacular, perhaps even the most significant, in the history of geodesy. An analysis of these developments is not within the scope of this article, which is intended to present an overview of the history of the adoption of official reference models. We simply mention that after the first order-ofmagnitude jump in accuracy of f through its surrogate J_2 , a steady cumulative improvement continued to flow in for Ja and GM from a variety of space-based observations. Just as Important a factor in opening up the question of improved reference models was a psychological shift in geodelic viewpoints around this time. An influx of people who were trained primarily in other fields like astronomy and engineering influenced the classical geodetic outlook. In retrospect, it is not surprising that the astronomers took the first concrete official step toward revising the international ellipsoid, since they were unaffected by the burden of recalculating triangulation points or map corners. The International Astronomical Union (IAU), organized the

same year as the IUGG, in 1919, faced a much broader problem—that of reviewing and formalizing a system of astronomical constants. The four parameters that defined the normal ellipsoid occupied the IAU only peripherally. However, once it was decided to consider revisions, it was logical to examine critically all the constants in current usage. In particular, the International ellipsoid values of a and I, and the International gravity formula of 1930 were part of this system. In May 1963, the fAU organized a special symposium in Paris on the system of astronomical constants. It was agreed that a working group would be formed to prepare recommendations to be presented formally to the next IAU General Assembly, which would take place the following year. But before then, and just after the Paris symposium, the IAG held its 13th General Assembly in Berkeley. The Paris meeting was duly noted, and a small committee was formed to serve as liaison with the IAU 'to make known the point of view of the IAG' (Bulletin Geodesique, New Series 70, 1963, p. 304). But the conservative bent of the IAG was evidenced by the passage of a resolution that 'no change should be made at the present time in the International gravity formula' (Bulletin Geodesique, ibid, p. 408).

At the IAU General Assembly in Hamburg in 1964, the following parameters were adopted: a = 6.378,160 m; $J_2 =$ 0.0010827; and $GM = 398,603(10^9)$ m³/s². From other primary astronomic constants, one can derive [Bulletin Géodésique, 1970] $\omega = 7.2921151467(10^{-5})$ rad s⁻¹. The corresponding value of f is 1/298.25.

4

Although no uncertainties were listed, the IAU working group that made the recommendations stated that 'the true values of the primary constants are believed to be between the following limits: a-6.378,080 to 6.378,240 m; J_2- 0.0010824 to 0.0010829; and GM-398,600 to 398,606(10°) m³/s². (Bulletin Géodésique, New Series 75, 1965, p. 63). The values of J_2 and GM were based on space observations, while that of a depended primarily on the recent geodelic arc measurements. (For example, the solution of Chovitz and Fischer [1956] yielded a value of 6,378,135 \pm 30 m if f were

The IAG was thus presented with a fait accompli when its 14th General Assembly met in 1967 in Lucerne. There was still an attitude of ambivalence, as shown by this passage (freety translated from the French) from the report of J.-J. Levaliois, the IAG Secretary General:

The Association cannot indefinitely give the in ion that it has no interest in this question and let other organizations make the decisions which are incumbent on it, even if—as it appears to be the case—the problem does not appear to be of fundamental importance to its proper work. (Builetin Geodésique, New Series 86,

The IAG proceeded to pass a resolution, confirmed by the IUGG, that set up a Geodetic Reference System 1967 to supplant the 1924-1930 international model. The parameters selected were identical to the ones chosen by the IAU. In order to siress that the IAG had not bean left completely in the lurch, the resolution contained the somewhat plaintive phrase, 'considering . . . that the IAU in consultation with the IUGG has adopted . . .' (Bulletin Geodesique, ibid, p. 367; italics added for emphasia). The bald fact was that the IAU had taken the lead in a matter which traditionally was the responsibility of the IAG.

In a manner of making amends, the IAG authorized and carried out a definitive development of derived constants and lables for the normal ellipsoid. These were published in a special issue of the Bulletin Geodésique [1970], and they contained a new standard gravity formula to replace that of 1930. The change in the value of y, (cf., table of official val-

ues of parameters) was due largely to an updating of the reference origin for absolute gravity. In addition, a detailed analysis of the effect of the atmosphere was made. The atmosphere has discernible mass, which artificial satellites 'consider' to be part of M. On the other hand, it is exterior to the surface. The problem is resolved by condensing the mass onto the surface. For points inside the atmosphere (as opposed to points outside, like artificial satellites), a correction table was prepared to be added to measured gravity. The correction varies from 0.87 mGal at the surface to 0.01 mGal at 32-km height,

The Geodetic Reference System 1980

Even at the time of the 1967 General Assembly, sufficient new data had been amassed that it was recognized that the 1967 parameters could be already improved. For example, Veis [1968] published a = 6,378,142 m, GM =3.986009(10¹⁴) m³s⁻², and J_2 = 108,263.9(10⁻⁸), based on a combination of the latest space and terrestrial observations. But the only action taken in this respect at the 15th General Assembly of the IAG and IUGG in Moscow in 1971 was to confirm the 1967 normal ellipsoid by adopting the special publication of the Bulletin Géodésique [1970] as the official statement of the IAG about a reference model. However, the IAG initiated a more positive attitude than in the previous decade. Perhaps it had the premonition that the IAU would revise its 1964 set of astronomical constants at its general assembly to be held in 1976. At a meeting of the IAG Executive Committee in February 1974, a special study group of the IAG was authorized. Their charge was to advise the IAG on the most up-to-date values of 'fundamental geodetic constants,' of which the four parameters of the normal ellipsold constituted a subset.

Accelerated activity by the IAG, starting in 1974 and culminating eventually in the replacement of the 1967 reference system, was mainly due to the work of this study group, and in particular to the energetic leadership of its president, Hel-

For the 16th General Assembly of the IAG at Grenoble in 1975, the study group recommended the following values as 'currently representative estimates': $a = 6,378,140 \pm 5 \,\mathrm{m}$; = 108,263 ± 1(10⁻⁸); $GM = 3,986,005 \pm 3 (10^8) \text{ m}^3\text{s}^{-2}$; ω = 7.292,115(10⁻¹¹) rad s⁻¹.

The change from the 1967 set is not trivial. Both J_2 and GMare given to one higher order of magnitude, and a is altered by 1 part in 300,000. The reasons for rounding ω down from 11 to 7 significant digits were, first, because variations of the annual mean value of ω could affect the eighth figure, and, second, seven digits correspond to the accuracy of the other

This set was presented as part of a more comprehensive collection of constants, including values of other spherical harmonic coefficients of the earth's potential field. Thus the overall group of constants does not define a normal ellipsoid. This was not the intent of the study group, since in its report (Bulletin Géodésique, New Series 118, 1975, p. 405) it advocated that the Geodetic Reference System 1967 remain 'the system officially recommended by the IAG, because too frequent a change is not advisable.' The IAG took this advice by approving, at Grenoble, a resolution that listed the values given by the study group 'as currently representative estimates' but also stating that 'this resolution does not affect the validity of the Geodelic Reference System 1967 for reference purposes.' Again, the conflict between the two purposes of an official reference system was manifested. A large segment of the delegates at the assembly took the point of view that a reference system loses its authority and cannot be taken seriously if it is frequently changed. (Perhaps there is a vague analogy with modern automobiles whose models are changed annually). On the other hand, the argument that change was costly to those in charge of issuing geodetically related products did not carry as much weight as before because of the availability of high-speed computers for effecting numerical transformations. Nevertheless, the IAG had postponed any official revision of its 1967 reference system until

The IAU did not labor under any such compunctions. At its 1976 General Assembly, also in Grenoble, it adopted as part of its latest set of astronomical constants the same values for \mathbf{a} , $\mathbf{J_2}$, and GM as had been recommended by the IAG study group and acknowledged by the IAG the year before.

The questions to be considered and resolved by the IAG at its next general assembly, at Canberra in 1979, were: first, should the 1987 reference system be changed, and second, if so, should the IAG again follow in the footsteps of the IAU or strike out boldly on its own. The specific recommendations in this matter again devolved on Moritz's study group, the tenure of which had been exter sembly. It is intriguing that attitudes and actions paralleled very closely what had occurred at the 2nd General Assembly in Madrid 55 years before. Concerning the first question, a strong majority of the study group members advocated that a new official reference system be adopted. The second question was not as easily resolved. The study group revised the 1976 'currently representative estimates' as follows; a = 6,378,137 ± 2 m; $J_2 = 108,263 \pm 1(10^{-8})$; $GM = 3,986,006 \pm 0.5(10^{-8})$ m³8⁻²; $\omega = 7,292,115(10^{-11})$ rad s⁻¹. Of these, GM, J_2 , and ω were not controversial; no recent evidence (except for additional data confirming the value of GM) had turned up to refine the values named by the study group in 1975 and subsequently adopted by the IAU. But a great deal of new evidence had accumulated for a, especially from the altimeter data acquired from the GEOS 3 satellite. The value 6,378,140 m implied an accuracy to six significant figures, whereas it was now believed that the uncertainty in a had been reduced to 2 or 3 m at the most. The latest solutions pointed to 6,378,137 m as the most likely value if a listing to seven figures was to be given. The argument against this was that luture refinements could very well converge on 138 or 136, and so seven figures should not be listed until one is sure of the seventh figure. The proponents of seven figures believed it was better and more accurate to be in error

possibly by a meter or two than to neglect entirely the infor-

Forum

GIFT

Something that has not been mentioned yet in the appear for gifts to AGU is the possibility of funding a scholarship that would be administered by the AGU. To keep geophys. ics an alive and vital discipline, we must continue to attract the best young minds to the field. If we established a wellendowed fund with sufficient resources to more than adequately fund a graduate student through 2 or possibly 3 years of graduate work, the attendant publicity and nationwide attention could do much to attract these good young minds to our field.

In your talks with potential donors I urge you to keep the possibility of scholarship endowments in mind,

> C. T. Russell, Chairman AGU Committee on Education and Human Resources

Whenever potential uses of an endowment fund have been discussed, the needs for scholarship assistance have been emphasized and given high priority. This point should have been included in the initial brochure, 'AGU—Girding For Tomorrow,' of the appeal. We will have other opportunitles to restate the goals. A 5-year effort has many win-

Through the fine work of your committee and others, the Union has undertaken a modest scholarship program. The support for this program has been charged to 'operational' funds and not drawn from the income of the existing endowment fund. The 1981 budget adopted by the Council at its December meeting in San Francisco includes grants for the continuing program to encourage students from minority groups to enter geophysics (see Eos, March 11, 1980) and for the Congressional Science Fellow Program. There is a scholarship for a woman in the atmospheric sciences funded through gifts from June Bacon-Bercy. Also, the income from the Berkner Fund, which is being treated as an endowment fund, is being used to pay dues for an initial 3year period for young geophysicists who live in developing countries. We believe that about 50 such grants can be made each year.

I recognize that these examples are mere tokens of the type of scholarship program that might be developed under a well-supported endowment fund. I hope that other members of AGU are as concerned as you. There are opportunities for donors and groups of donors to identify their gifts as a scholarship fund in memory of a colleague or former professor. These are decisions for the donors.

> Charles A. Whitten Earl G. Droessler Cochairmen, GIFT Steering Committee

mation provided by the seventh figure. Compatibility with the IAU was not a concern because the slightness of the change would have insignificant effect on the system of astronomical constants (P. K. Seldelman, private communication to H.

At the 17th General Assembly of the IAG, at Canberrain December 1979, an entire half-day was devoted to a presentation and discussion of the proposed reference system. The bold' approach triumphed by a larger margin than the correspondingly bold action taken by the Second Assembly at Madrid in 1924. (Since the number of delegates was much greater, an actual vote count at Canberra was neither feasible nor needed, majority sentiment being readily evident.) Thereby, the IAG forwarded to the IUGG the following resolution, which was approved and published as IUGG Resolution

IUGG recognizing that the Geodetic Reference System 1967 adopted at the XIV General Assembly of IUGG, Lucerne, 1967 no longer represented the size, shape and gravity field of the Earth to an accuracy adequate for many geodetic, geophysical, astronomical and hydrographic applications and

Considering that more appropriate values are now

Recommends

(a) that the Geodetic Reference System 1967 be replaced by a new Geodetic Reference System 1980, also based on the theory of the geocentric equipotential ellipsold, conventional constants defined by the following equatorial radius of the Earth:

a = 6,378,137 m

geocentric gravitational constant of the Earth (including the atmosphere)

 $G\dot{M} = 3.986,005 \times 10^8 \,\mathrm{m}^3\mathrm{s}^{-2}$

Size and Uncertainty of Parameters

Parameter, units	Order of Magnitude	Uncertainty, ca. 1900	Uncertainty 1980
a, m / J ₂	6 (10 ⁶) 1/300 10 ⁻³	1/2 (10 ⁴) 1/10 ²	1/3 (10 ⁸) 1/10 ⁶
GM, m ³ 8 ⁻² γ _e , m.s ⁻² ω, s ⁻¹	4 (10 ¹⁴) 10 ¹	1/10 ² 1/10 ⁴ 1/2 (10 <u>4</u>)	1/10 ⁸ 1/10 ⁷ 1/2 (10 ⁶)
	7 (10 ⁻⁵) nate of deviation	1/3 (10 ⁷)*	1/3 (10')" .

Official Values of Parameters

System	<i>a</i> , m	1	J ₂	GM, m ³ a-2			
1924-30 1967 1980	6,378,388 6,378,160 6,378,137	1/297.0 1/298.247* 1/298.257*	0.0010920° 0.0010827 0.00108263	3.98633 (10 ¹⁴)* 3.98603 (10 ¹⁴) 3.986005 (10 ¹⁴)	γ _{e'} m s ⁻² 9.780490 9.780318°	ω, rad s ⁻¹ 7.292115 (10 ⁻⁵) 7.2921151467 (10 ⁻⁵)	8
				O.800008 (10·1)	9.780327*	7.292115 (10-5)	1

*Computed from the other parameters

dynamical form factor of the Earth, excluding the permanent tidal deformation:

 $J_2 = 108,263 \times 10^{-8}$

angular velocity of the Earth:

 $\omega = 7,292,115 \times 10^{-11} \,\mathrm{rad}\,\mathrm{s}^{-1}$

(b) that the same computational formulas, adopted at the XV General Assembly of IUGG in Moscow 1971 and published by IAG, be used as for the Geodetic Reference System 1967, and

(c) that the minor axis of the reference ellipsoid, defined above, be parallel to the direction defined by the Conventional International Origin, and that the primary meridian be parallel to the zero meridian of the Bureau International de l'Heure adopted longitudes.

The phrase 'excluding the permanent tidal deformation' is intended to emphasize that the normal value of J_2 should be due entirely to self gravitation and exclude the effect of the sun and moon. Paragraph (c) precisely orients the normal ellosoid in inertial space. This is vital because, for geodetic reference purposes, orientation is just as crucial as scale.

The IAG Executive Committee authorized the special study group to continue to monitor the state of the art in geodetic constants and to report at the next (1983) IUGG General Assembly. However, any recommendation at that time to

change the Geodetic Reference System 1980 is hardly concelvable. It is a fair guess that this latest model may see us through this century.

Acknowledgment

Much of the information in this article was culled from various issues of the Bulletin Géodésique, going back to its inception in 1922. I hope it will not be considered presumptuous of me to dedicate this article to the memories of Georges Perrier, founder and editor of the lietin Geodesique between the two World Wars, and Pierre Tardi, editor from 1946 to 1951, and to their successors: Jean-Jacques Levaliols, editor from 1952 to 1964, Michel Louis, editor from 1965 to 1975, and Ivan Mueller, the present editor. Of course, any errors in this narrative are solely my responsibility

References

Bulletin Geodésique, Special Publ., Geodetic Reference System 1967, Int. Assoc. Geod., Paris, 1970.

Cassinis, G., Sur l'adoption d'une formule internationale pour la pesanteur normale, *Bull. Geod.*, 26, 40-49, 1930. Chovitz, B., and I. Fischer, A new determination of the figure of the

earth from arcs, EOS Trans. AGU, 37, 534-545, 1956. lelskanen, W., and H. Moritz, *Physical Geodesy*, W. H. Freeman, San Francisco, 1987. Helmen, F. R., Mathematischen und Physikalischen Theorieen der

Höheren Geodäsie, Teubner, Leipzig, 1880. Lamben, W., La ligure de la Terre et le nouvel ellipsoide de réference internationale, Bull. Geod., 10, 81-99, 1926.

Moritz, H., Density distributions for the equipotential ellipsoid, Rep. 115, Dep. Geod. Sci. Ohio State Univ., Columbus, Ohio, 1968.

Schmid, E., Preliminary values of the effipsoid obtained by using delections of the vertical, based on the North American 1927 Datum, in Haylord's computations (abstract), Bull. Geod. New Ser

Strasser, G., Ellipsoldische Parameter der Erdligur, in Deutsche Geodásie. Kommission beider Bayerischen Akademie der Wiss-enschaften, Reihe A, Theoretische Geodásie, vol. 19, 1957. Veis, G., The determination of the radius of the earth and other geodelic parameters as derived from optical satellite data, Bull. Geod., New Ser. 89, 265, 1968.



Bernard H. Chovitz is director of the Geodetic Research and Development Laboratory in the National Ocean Survey of NOAA. His educational background includes degrees in mathematics from the College of William and Mary and Harvard University. He has been working in the field of goodesy since 1948 when he joined the Army Map Service after a stint in the Navy during World War II. His principal interests in geodesy have been directed to theoretical aspects and to applications of satellites. He is a past president of the Section on Space Techniques of the International Association of Geodesy (IAG) and remains a member of the IAG Executive Committee, He has been actively involved in the American Geophysical Union, having coedited one of the monograph series, served as an associate editor of the Red JGR, and recently completed a term as president of the Geodesy Section.

News

Big Science Victim of Budget Game

In an apparent effort to make certain that the newly proposed cuts in the federal budget reach all factions, except of course those that involve the military-industrial complex, David Stockman, the key player of the 'budget game,' has leaked to the press some of his plans that could virtually eliminate many parts of big science over the next decade. Two agencies that are important in this respect, and important to a large proportion of the geophysical community, are NASA and NOAA. There are portions of the budgets of both of these agencies that because of military significance will go unscathed. Unfortunately the 'across-the-board' cuts proposed by OMB Director Stockman will have to be concentrated on the rest that are relatively indefensible from a military standpoint and that turn out to be the most science

in an account apparently leaked to the Chicago Sun-Times and reported by that newspaper on Feb. 4, 1981, Stockman, one of the inventors of the term 'economic Dunkirk, is said to have placed the science-oriented segments

of the federal government on a 'hit list.' The projected cut to the NASA budget recently proposed by the Carter administration is stated to be on the order of

\$630 million, amounting to almost 10%. It is true that the fiscal year 1982 budget request for NASA exceeded the fiscal year 1981 actual budget by upwards of 22%. The probiem is that aside from inflationary increases, including supplementary salary rates that are beyond the control of the agency, the major portion of the increase is in space transportation, i.e., shuttle. Possibly shuttle itself may be curtalled in its later missions, but right now there is a great push, and there are extra costs to get shuttle off the ground.

The proposed budget cuts for NASA fit the overall effort of the new administration to place intense pressure upon the federal government. In this context, and in the context of a numerical 'budget game,' the cuts appear reasonable and perhaps, logical. If these cuts are indeed made, their ntation will be less than logical. NASA would have to curtail its space science program by more than one third. In doing this, all new missions would have to be cancelled, and in essence there would be no effective space science ogram at all. The two new missions, Galileo and VOIR, would be scrapped. So would the Gamma Ray Observatory, the Upper Atmosphere Exploration Program—possibly the Space Telescope, and many others. One sees the perspective in realizing that if approved, the Stockman plan would virtually put the Jet Propulsion Laboratory at Cal-Tech out of business, and eliminate it as the world center of space research within the next few years.

The cuts to other agencies, for example, NOAA and the U.S. Geological Survey, have not been so specifically targeted at this time. Nonetheless, NOAA has been told that it can expect major cuts in its NOS satellite program and in the sea grant program. The NOS satellite program, which is funded at a level of several tens of millions of dollars, is to be eliminated entirely. The cut proposed for the sea grant program is slated at over \$21 million, which would mean a reduction of the program by one half in 2 years.

Some Washington analysis view the Stockman 'hit list' as a series of 'trial balloons.' Great resistance and outcry from the communities and sectors to be victimized possibly could reduce or, in some cases, even eliminate specific cuts. Because the budget has already been proposed to Congress by the outgoing administration, it is anticipated that many of the budget outs proposed by the new administration and the budget outs proposed by the new administration. tration may not be approved by the Senate and by the douse. The congressional committees and subcommittees that handle these issues will be sensitive, hopefully, to the outcries of the nation -- PMB 88

'Wind Farm' Producing Electric Power

The nation's first 'wind farm,' featuring three of the largest advanced wind turbine systems, is nearing completion. The turbines are the seventh, eighth, and ninth wind turbines to be built under a portion of the federal wind energy program. The first of the three new machines began producing electricity for the Bonneville Power Administration at Goodnoe Hills, near Goldendale, Wash., late last year. The second machine will be fully assembled and begin to generate electricity in February. The third machine is expected to be fully assembled and running late this spring

The three machines, each rated at 2500 kW, will be the first cluster of these experimental wind turbine systems. The new machines have been designed to bring the cost of wind-generated electricity very close to the cost of power generated through the burning of fossil fuels.

When all three are operating, by mid-1981, they will feed 7500 kW of electricity into the Bonneville power grid. enough to supply 2000 to 3000 average homes. Designated Mod-2, the machines are the largest and most powerful wind turbines ever built. The three Goldendale wind turbines, designed to have a system life of 30 years, were built by the Boeing Engineering and Construction Co. of Seattle, Wash., under contract to NASA-Lewis. Under earlier Department of Energy funded projects, started in 1974, NASA-Lewis built six smaller developmental units, ranging in power output from 100 to 2000 kW.

in terms of design, size, appearance, and performance. the new machines encompass significant modifications and advancements over the earlier models. These first three Mod-2 prototype wind turbines cost \$13 million to build and install. It is estimated that they will produce electricity at a cost of less than 8 cents per kWh. If these same machines were to be produced in quantities of 100 per year or more, the 100th wind turbine would provide power at a cost of less than 5 cents per kWh.

The Goodnoe Hills machines are set up in a triangular attern, ranging from 460 to 915 m apart, to form a small turbine 'farm.' Engineers predict that farms of 25, 50, or 100 wind turbines may be producing truly significant amounts of cost-effective electricity by the end of the cen-

The new, Mod-2 wind turbines are 61 m high and produce power from the rotation of their steel rotor blades. which measure 91 m from tip to tip. Each machine's rated power output of 2500 kW is achieved at a blade speed of 17.5 rom in a rated wind speed at the lop of the tower of 44 km/h. (Rated wind speed is defined as the lowest wind apped at which full power can be achieved.) The power output in relation to the wind speed is regulated by varying the pitch of the 13.7-m-long articulated blade tips.

It takes 22.5 km/h of wind to start the blades rotating. and at a wind speed of 72 km/h the machine is designed to shut itself off to preclude both excess stress on the blades and possible damage, However, in a stationary mode the machine can withstand winds up to 200 km/h. A drive train. Including an improved, three-stage planetary gear box, converts the 17.5 revolutions of the blade into 1800 rpm's of

Among the major design innovations and cost-savings difications that have been incorporated into the Mod-2 wind turbines are

Blade tip control: Unlike their predecessors, which were leathered along their full length, the speed of the Mod-2's blades is controlled by varying the pitch of only the 13.7-m-long blade tips. This has enabled designers to reduce rotor

weight and cost. Tower: Towers for all prior machines were of rigid trues design: These have been replaced by the more flexible,

simpler, tubular design, a modification that has permitted the use of less expensive, factory-assembled components and an overall reduction in the amount of materials required for tower construction.

Rotor blades: The welded steel blades are fastened to the hub in a straight-line fashion and are positioned upwind of the tower

Through the use of a teetering mechanism at the hub, the blade assembly is able to till as much as 6° in response to wind loads. This design feature reduces loads on all of the turbine components and has resulted in lower costs.—PMB &

World Earthquake Activity Increases

The number of significant earthquakes in the world increased in 1980, and the earthquake death toll was up sharply, according to the U.S. Geological Survey.

USGS scientists said there were 71 significant earthquakes recorded in the world last year, compared to 56 the previous year and 62 in 1978. Eleven of the 1980 earthquakes occurred in the United States, compared to five the previous year and four In 1978.

Significant earthquakes are defined as those registering 6.5 or more on the Richter scale, or smaller ones that cause casualties or considerable damage.

About 7140 earthquake-related deaths occurred in 1980, nearly five times as many as in 1979, but still below the long-term average of 10,000 deaths per year.

Most of the deaths in 1980 occurred during or after the quakes in Algeria and Italy. More than 3500 persons were killed in a 7.3-magnitude tremor and a 6.2-magnitude aftershock in Algeria October 10, and more than 3000 persons were reported killed in a 7.2-magnitude quake in southern Italy November 23. 88

Study To Examine Wind-Driven Currents

The effects of the wind on currents along northern California will be examined under a \$6.4 million study beginning April 1. The 4-year program, called Coastal Ocean Science Foundation. Oceanographers from five institutions will participate.

Focus of the study will be on the physical conditions involved in ocean movement, including water and air temperatures, and wind speed and direction. CODE's overall objective is to identify and quantify the processes that govern wind-driven currents over the continental shelf along a 97-km stretch of California, Data from Point Arena to Bodega Bay will be collected by using moored instruments, floating buoys, shipboard observations, land-based stations, and aircraft,

CODE is a joint project of the Scripps institution of Oceanography, Woods Hole Oceanographic Institution, Oregon State University, the University of New Hampshire, and the U.S. Geological Survey.

'From a purely scientific viewpoint, we want to know the direction of the current, how last it travels, and what forces drive it, said Clinton Winant, one of the principal investigators and an oceanographer at Scripps. From an applied point of view, the study is important because of the increased use of coastal water by society—for disposal of wastes, oil exploration, and commercial fishing," Winant continued. 'Knowledge of the coastal circulation will aid in management of these resources and the monitoring of po-

tential hazards such as oil spills and other pollution. 'If we are successful in understanding the physics which relate motive forces to the currents. Winant added, then we should have predictive models that could be applied for conditions at similar areas anywhere in the world. As part of the program two 4-month periods of extensive

study are planned: one for April 1 to July 31, 1981, and another for the same time one year later. Ocean circulation at the shelf will be measured and recorded during these periods, Winant said.—BTS 🕱

Project Alms to Improve Weather Predictions

Project Skywater, an almospheric research program slated to begin this spring, will investigate basic precipitation problems, including the formation of raindrops, mechanisms by which air outside rainclouds mixes with air inside, atmospheric processes that lead to the birth and growth of a storm, and the origins of ice. These fundamental problems stand in the way of evaluating the potential of weather modification techniques and of predicting precipitation and severe weather,' according to Bernard A. Silverman, project

As part of the project, researchers will work this summer on the Cooperative Convective Precipitation Experiment (CCOPE). Based in Miles City, Montana, CCOPE will study the lifetimes of summer clouds. The work will focus on the major natural processes that lead to precipitation in large cloud systems. In addition, researchers will investigate cloud chemistry and lightning's effect on rainfall.

About 125 scientists from 17 universities and more than a dozen private research groups will participate, Silverman said. Project Skywater is funded through the Department of the Interior's Water and Power Resources Service. \$3.

Geophysicists

Bernice Ackerman has been appointed head of the new meteorology section of the Illinois State Water Survey. She has been a professional scientist and a project leader at the Water Survey since 1972.



John R. Filson has been appointed chief of the Office of Earthquake Studies at the U.S. Geological Survey National Center in Reston, Virginia. He succeeds Robert L. Wesson.

Paul S. Julienne, a staff member of the Department of Commerce's National Bureau of Standards, received a bronze medal at the Eighth Annual NBS Awards Ceremony. The medal was awarded for his contributions to the development of theoretical descriptions of atomic collisions in intense electromagnelic fields.

New Publications

New Listings

Items listed in New Publications can be ordered directly from the publisher; they are not available through AGU.

Geomorphology—A Systematic Analysis of Late Cenozoic Landforms, A. L. Bloom, Prentice-Hall, Englewood Cliffs, New Jersey, xvii + 510 pp., 1978. The Geotectonic Development of California, Rubey, vol. 1,

W. G. Ernst (Ed.), Prentice-Hall, Englewood Cliffs, N.J., xll + 706 pp., 1981, \$25.00.

Groundwater Hydrology—Second Edition, D. K. Todd, John Wiley, New York, xiii + 535 pp., 1980. illinois State Geological Survey: its History and Activities,

Educ. Ser. 12, R. E. Bergstrom, Illinois State Geological Survey, Urbana, iv + 41 pp., 1980. IMS In Antarctica, Mem. Nat. Inst. Polar Res. Spec. Issue

16, T. Hirasawa (Ed.), National Institute of Polar Research, Tokyo, v + 144 pp., 1980.

The Interpretation of ionic Conductivity in Liquids, S. I. Smedley, Plenum, New York, xvi + 195 pp., 1980, \$25.00. An Introduction to Atmospheric Physics, 2nd Ed., Int. Geophys. Ser. Vol. 25, R. G. Fleagle, J. A. Businger, Academic, New York, xiv + 432 pp., 1980, \$29.50.

An Introduction to Atmospheric Radiation, Int. Geophys. Ser. -Vol. 26, K.-N. Liou, Academic, New York, xll + 392 pp., 1980, \$32.50.

Classified

EOS offers classified space for Positions Available, Positions Wanted, and Services, Supplies, Courses, and Announcements. There are no discounts or ions on classified ads. Any type that is not publisher's choice is charged for at display rates. EOS is published weekly on Tuesday. Ada must be seceived in writing on Monday 1 week prior to the late of the issue required.

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3eophysicisLStructural Geologist, Albion College. A lenure track position, commencing Fall 1981, is open at the assistant professor level at Albion College's Department of Geological Sciences. The position involves teaching undergraduate laboratory courses in structural geology and geophysics and introductory lab courses or non-lab courses in geology. The Department is developing a geophys-cs geology major and has some geophysical equipment. Candidates with a Ph D. or who are about to acquire a Ph.D are preferred

Depending upon the applicant's background, the new stall member may have the opportunity to assist in teaching at Albion's geology field camp for additional remuneration. A 6-week summer field methods course is offered to students from many olleges and universities at the field camp located

Director: Meteorology Division, Air Force Geophysics Laboratory invites applications for the position of Director of the Meteorology Division located at Hanscom Air Force Base, Massachusetts. The Division is responsible for Air Force research and development in meteorology, atmospheric physics, remote and direct sensing technology, climatology, and relative technologies. The division director provides overall direction to an R&D program when employs over 80 people and covers a broad learn or which employs over 80 people and covers a broad range of in-house and contractual actentific investigation. A candidate should have a record of distinguished achievement in meteorology/atmospheric physics as a research scionist and manager of a substantial R&D unit. This position is Air Force Senior Executive Service with a select case of \$55 0.47 to ecutive Service with a salary range of \$52,247 to \$57,673, subject to current \$50,112 celling. For an application package, call collect: Robert Ellerin, (617) 881-2896. To be considered, applications must be returned by 30 April 1981.

Marine Geologist. Dalhousie University, Department of Oceanography Invites applications for a tenure track assistant, or possibly associate professorship. The person appointed will be expected to develop a strong research programme (for which funding opportunities exist through NSERC Strategic Grants in Oceanography) and to teach and supervise graduate students. We particularly solicit applications from people with interests in one or more of sedimentality. more of: sedimentology, strattgraphy, sedimentary geochemistry and paleo-oceanography. We actively geochemistry and paseo-oceanography, we actively cooperate with the geology department and the tederal government (Bedford Institute of Oceanography). Applications with c.v.'s and names of three referees should be sent before May 1 to Prof. C. Beaumont, Department of Oceanography Beaumont, Department of Oceanography, Dalhou-sia University, Halifax, Nova Scotla, B3H 4J1, Canada. Telephone numbers are 902-424-3557/3779, Telex 019-21863, Attention: Oceanography.

Sediment Transport/Geological Oceanog-raphy, North Carolina State University. A tenure track position is available in the Departs Marine, East position is available in the Department of Marine, East Atmospheric Sciences at the level of assistant or associate professor. Applicants should have a thorough understanding of sediment transport, and a general background in geological oceanography. A Ph.D. is required. The candidate will be expected to strangitude the graphical translate. will be expected to strengthen the graduate teaching and research programs. The applicant's research interests can be theoretical, experimental, or observational, but must involve quantitative examination of marine sediment transport. Applicants should for-ward a resume, including a list of courses taken: laught, and the names of at least three references to Dr. Charles A. Nittrouer, Chalman, Search Commit-lee, P.O. Box 5068, NC State University, Raleigh, NC, 27850, Application materials should be sent by

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A synthesis of marine grophysical/geological

This volume will serve as a logical starting

certers leader \$30 must be prepa

point for many future studies of this area.

and related fectionic information that could serve

to identify important gaps in our information

new of continuing investigations

base and focus attention on crucial areas for

Division Director Atmospheric Analysis and Prediction Division (AAP) National Center for Atmospheric Research. The National Center for Atmospheric Research (NCAR) in Boulder, Colorado seeks applications and nominations for director of its AAP division, which concentrates on theoretical and observational studies of the dynamics and thermodynamics of the lower almosphere. AAP's four sections emphasize climate research, large-scale dynamics, physical

ceanography, and mesoscale research. The division director is the scientific and administrative leader of the division, responsible for overall scientific productivity and excellence; short and long range planning, staffing, including affirmative action, and budget management.

The position requires a Ph.D. or equivalent in

physical science; demonstrated scientific productive ty and breadth in areas of AAP interest equivalent to highest level NCAR-scientific appointment; judg-ment about scientific quality, strategies and individ-ual competence; experience in management of ac-tivities and budgels; and ability as a scientific advo-

Please send a letter of candidacy and a curriculum vitae to Dr. G. William Curis, P.O. Box 3000, Boulder, Colorado 80307. (303-494-5151, Ext. 550) Applications should be received by 15 April 1981. The selected candidate should expect to assume position by 1 September 1981 or as soon thereafter

NCAR is an equal opportunity/affirmative action

Acadia University. The Department of Geology, Acadia University, is seeking a head, beginning July 1, 1981. Preference will be given to applicants with experience and research interests in petrole gy and related fields and/or energy resources. tank and salary will be appropriate to qualificat The successful candidate will assume leadership of an established, vigorous and growing department with five faculty members, and over 100 B.Sc. and at undergraduate and graduate levels, and academic

lanning and development in the specialty area.

A letter of application together with a curriculum rilae and names of three referees should be sent by March 15, 1981 to Dr. Earneat E. Zinck, Dean of Science, Acadia University, Wolfville, N.S., BOP 1X0.

Dean of Sciences and Mathematics/Hunter Gollege, City University of New York.
Chairenging position available July 1981, in dynamic urban institution. Strong doctoral research programs, extensive federal funding, major commitment to women and minorities, MBS and MARC programs, stable envoluments. programs, stable enrollments, major expansion of facilities in progress, attractive midtown Manhattar location. Send resume and names of three refer ir, Search Committee for Dean of Sciences and Mathematics, Box 447, Hunter College, 895 Park Avenue, New York, NY 10021.

Exploration Geophysicist/University of Okiahoma. The School of Geology and Geophysics at the University of Okiahoma will hire an experienced exploration geophysiciet to till the Frank and Beity Schultz Professorehip, and is seeking nominations and applications for the position. The person must be a distinguished scientist who has made important contributions to exploration geophysics through research. Professore will be chosen physics through research. Preference will be given to a scientist whose specially is selamic propertie of earth materials and who has earned the Ph.D. The Schultz Professor will provide leadership and guidance in establishing a quality teaching and research exploration geophysics group. The University of Oklahoma has recently made a strong commitment to the earth sciences with the establish ment of a College of Geosciences, to be housed in a new building. The School of Geology and Geophysics will expand from its present faculty of 16 to 26 faculty members by 1986. This will include three scientists in the exploration geophysics area, five in structure-tectonophysics-solid earth geophysics and others in stratigraphy-paleontology, geochemistry-

atrology, and energy resources.

Applications are due April 30, 1981. inquiries, nominations, and applications should be sent to John Wickham, Director, School of Gaology and Geophysics, University of Oklahoma, Norman, OK

The University of Oklahoma is an equal opportu-

hemistry/Brittle Deformation, Univeraity of New Brunswick. The Department of gy has a tenure track position available from July 1, 1981 at assistant professor or higher level. The successful applicant will be expected to teach both undergraduates and graduates as well as car rying out research and supervising graduate atu-

Applications will be accepted in the following fields: geochemistry of ore bodies, exploration, environmental or soil geochemistry, brittle deformation, rock mechanics or site engineering.

Applicants should have a Ph.D. and preferably, post doctoral experience. Applications including a curriculum vitae and names of three referees should be sent to P. F. Williams, Chairman, Department of Geology, University of New Brunswick, Fredericton, N.B. E3B 5A3,

Pearch Plasma Physicist. Berkeley Scholars, Inc. has opening in D.C. area. Must be eligible for Ph.D. in plasma physics with specializaton in and abstracts presented on theory and nu-merical simulation of magnetic shear effects on in stability phenomena as applied to lonospheric and magnetospheric problems. 1 year work experience in the field is required. Salary is \$24,415 per yr., 40 Scholars, Inc., P.O. Box 983, Berkeley, California An AA/EOE.

MICROPROBE SPECIALISTS

Seeking specialists to maintain and upgrade the electron microprobe facility at the Johnson Space Center. Successful applicants should have experience with the operation of an

electron microprobe and/or SEM and a sound understanding of the theory of X-ray analysis. Experience with computers and computer programming is highly desirable. Familiarity with geological samples is preferred. Time will be available to pursue individual interests on the microprobe or other laboratories at NASA/JSC. Prefer applicants, with BS/MS degrees plus experience in related fields.

Send resume in confidence to William R. Jancha at Lockheed Engineer-Ing & Management Services Company, Dept. C-20-EOS, 1830 NASA Road #1, Houston, Texas 77058.

LOCKHEED

An equal opportunity employer, M/F/H.

Faculty Appointment/Colorado State University. The Department of Earth Resources, Colorado State University Invites applications for a enure track appointment with emphasis on active rech experience in remote sensing, and an interest search experience in teaching graduate and undergraduate students beninning September 1981. The candidate is expedied to have a Ph.D. degree in geology, waterahad sciences or in a related field and le expected to derelog and maintain a vigorous research program with pecial emphasis on the application of state-of-theart remote sensing techniques to the investigation o natural resource phenomena. The candidate is expected to teach undergraduate and graduate courses in the application of remote sensing to natu-

Rank and salary are open and dependent on expece and qualifications of the applicant Applicants are invited to submit curriculum vitae, three letters of reference and a letter describing research and teaching interests to Dr. H. S. Boyne. Department of Earth Resources, Colorado State University, Fort Collins, Colorado 80523/(303) 491-Deadline for receipt of applications is April 15.

CSU is an EOE/AA. E.O. Office: 314 Student Serv.

nographic Mooring Technician. The rine Science Program at North Carolina State University (Rateigh) is expanding its oceanograp echnical services group and is currently seeking a chriden familier with the design and deployment o deep-sea current meter mooring arrays, as well as with standard shipboard oceanographic sampling

echniques. Qualifications include a degree in science or engineering with some electronics background and two years field experience or an equivalent combination of education and experience. Salary commensurate with education and experience. Send resume and names of references to Personnel Services, North kina State University, P.O. Box 5087, Raleigh,

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Virginia Polytechnic Institute and State University. Igneous Petrology and Geochem try/Research Associate. Origin and tectonic signifi-cance of granitic rocks. Project involves petrography nistry, mineral chemistry, isotopic stud-

les, and field mapping. Send résumés to: D. R. Wones, Chairman Department of Geological Sciences Virginia Poly. Inst. and St. Univ. cksburg, VA 24061

The University is an equal opportunity/affirmative

Faculty Positions in Geology/University of Alabama. The Department of Earth Science is seeking applicants for a tenure track position at the volessor level. The Ph.D. degree is required. The selected person will teach one or more courses in geophysics at the undergraduate level, pask courses in earth science, will supervise senio Independent research projects, will develop one or more elective courses in that person's specialty, and

will develop a research program.

The Department of Earth Science consists of four tui-time faculty and graduates approximately ten seniors each year. Equipment and facilities include a geochemical and sedimentation laboratory, rock preparation equipment, student and research pet-rographic equipment, Bison setamographic equipment transit and alldade, drafting facilities, and comsuter equipment. Salary is competitive and commen-

surale with experience and education. Applicants should send a resume, three letters of reference, and a brief discussion of research interests to Michael J. Nellson, Earth Science Department, University of Alabama in Birmingham, Birmingnam, Ala. 35294, prior to May 1, 1981. The position

vil be available September, 1981. The University of Alabama in Birmingham is en itv/affirmative action employer.

Geophysicist North Carolina State Univeralty—Reieigh. The Department of Marine, Earth and Atmospheric Sciences invites appications for a presently available tenure track ion in geophysics. Rank and salary are open, anding on qualifications and experience. A Primary separativities will include generating

Primary responsibilities will include generating and conducting research programs as well as hing graduate courses in geophysics. The Partment currently consists of 31 regular ully members including 16 in the areas of ology and geophysics. Please send resume dinames of and names of three references to Prof. I. J. Won, Search Committee Chairman, Depart e, Earth and Atmospheric Sciences, North Carolina State University, Raielgh, NC 27650, USA. We hope to make a final decision prior to May 31, 1981.
North Carolina State University is an equal opportunity/affirmative action employer.

Physical Oceanographer/ Geophysical Fiuld Dynamicist

Areté Associates, a growing research firm, located in Southern California, engaged in libeoretical and empirical physical ocean-cyraphy, is offering permanent, full-time positions. Candidates require Ph.D. (or equivalent experience) in physical ocean-cyraphy or geophysical fluid dynamics. Salaries are competitive and negotiable, based on qualifications. Areté offers a fringe benefit package of superior quality. Cualified candidates should send résumé, salary history, and liet of professional reference. salary history, and list of professional refer-

> Personnel Administrator
> Areté Associates
> P.O. Box 350 Encino, CA 91316

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Geophysicist. The Geology Department at the University of Southwestern Louislana in Lalayette, Louislana invites applications for an anticipated research/teaching opening in geophysics. Responsibilities will include one-half time in seismic investigation of geopressured-geothermal reservoirs of south Louisians and one-half time leaching geophysics and supervising graduate students. The successful applicant will be familiar with exploration selemic deta acquisition, processing, and interpretation. The Ph.D. or Mesters with experience, is required. Salary range is \$23,000 to \$35,000 per 12 month. he position is expected to be filled in the Spring of

1981 or as soon as possible thereafter. To apply please direct a resume, three letters of tion, and any other perlinent materials to: Dr. Gary L. Kinsland, Geology Department, University of Southwestern Louisiana, Lafayetta, LA

GlaciologistUniversity of Washington. The University of Washington seeks appli-cations for a tenure track position with the individual to be appointed as assistant professor jointly in the Department of Almospheric Sciences and Geophys-ics program. Principal research interest of candidates should be directed toward geophysical or cli-mate related study of enow or ice. Candidates speclalizing in physical processes in snow are of particular, but not exclusive, interest. All applicants should be committed to graduate level teachin search advising, and innovative research emp sizing advanced experimental methods and rigorous sical analysis. Duties will include teaching one or two undergraduate courses per year in atmosphe sciences. The appointment starts in September 1981. A Ph.D. is required. For additional information call C. F. Raymond (206) 543-4914. Interested persone may send a resume and four letters of recommendation to Professor R. T. Merrill, Geophysics Program AK-50, University of Washington, Seatile,

Deadline for application is 31 March 1981.

Structural Geologist. The Department of Geosciences of Purdue University Invites applicate for a tenure track feculty position in structural geology, starting in August 1981. Flank and salary will be commensurate with qualifications. A Ph.D. is re ulred. The individual will be expected to teach undergraduate and graduate courses in structural geol-ogy and tectonics, participate in summer field Preference will be given to a candidate with an applied field orientation and a strong background in the quantitative analysis of field data. The department has active programs in petrology, geophysics, and engineering geology and has a close working relationship with the geotechnical group in civil engineer-ing and the Laboratory for Applications of Remote Sensing. Closing date for application is April 1, 1981. Applicants should send a resume, the names, adsees, and telephone numbers of three referees, and a brief statement of research interests to R. H. McCallister, Department of Geosciences, Purdue University, West Lafayette, IN 47907.

Purdue University is an equal opportunity/affirm

Staff Scientists/Ocean Margin Prilling Program. Joint Oceanographic institutions, inc. (JO inc.) has immediate openings for two staff scientists to fill the positions of:

-Field Programs Coordinato in its Ocean Margin Drilling (OMD) Science Programs Office. Individuals filling each of these positions will report to the OMO Chief Scientist. They will ed to provide staff support to advisory com mittees in their area of concern, and will be responthe OMD Science Advisory Committee, including oversight of the performance of individuals or groups under contract to JOI. Both positions require a Ph.D. in an appropriate area of earth science and appropriate experience. The OMDP is funded for FY 81.
Initial appointment will be for a period of two years with the second year contingent upon the avail-ability of funds. The positions may be filled on a ro-tating basis. Salary will be competitive. Send resume, statement of interest, and the names of three referees to Thomas A. Davies, Chief Scientist, Ocean Margin Drilling Program, Joint Oceanographic Insti-tutions, Inc., 2800 Virginia Ave, NW, Suite 512, Washington, DC 20037. The deadline for applica-tions is February 20, 1981, or as soon thereafter as suitable candidates are found.

Postdoctoral Research Associate. Oceanography Department of the Naval Postgraduate School seeks recent graduate to study the es, through numerical ocean mod of the physical oceanographic processes active in the vicinity of the arctic ice edge of Alaska. Problem es include the effects of the comp on the circulation and frontal formation, the dynami associated with interleaving of water masses at the ice edge, and the mechanisms involved in ice retreat. Research will be performed in the context of an observational program which has acquired data and leveloped insights over the course of several years.

Position is available March 1981 and is renewable annually. Salary depends upon qualifications. Send resume and the names and addresses of these references to Faculty Search Committee, Dept. of Oceanography, Naval Postgraduate School, Monterey, CA 83940.

Equal opportunity/affirmative action employer.

Solid Planet Geophysicist/Texas A&M University. The Department of Geophysics at Texas A&M University is pleased to announce availability of a junior level, tenure track faculty position. The department emphasizes solid earth geophysics with concentrations in tectorophysics, geodynamics and internal structure. We are seeking a talented and active researcher and teacher with will complement, strengthen, and broaden current areas of expertiee. There are excellent opportunities for inter-action and collaboration with members of our deaction and cotleboration with members of our departments as well as those in the departments of oceanography and gebiogy and in the center for tectonophysics. Qualified elements are requested to send resumes to Neville L. Carter Held, Department of Geophysics, Texas A&M University, College Station, TX 77843.

Texas A&M University is an aduat opportunity employer.

Assistant or Associate Scientist/Ocean Engineering. Research position in sediment transport and bottom boundary layer flows: must have background in turbulent boundary layer theory, laboratory or field boundary flow observation low sediment interaction. Interest in biologically modified soil properties and statistics of spatial sampling are desirable. Will participate in several rine and deep ocean sedimont transport/ boundary layer studies. Expected to collaborate with geologists, biologists, physical oceanographers, and ocean engineers in these studies. Opportunities to participate in graduate education program through advising students and formal courses. Recent graduate, up to five to ten years of experience with Ph.D. in engineering, geology, physics or mathematics. If interested, write to Department Chairman, Ocean Engineering Department, Box 64P, Woods Hole Oceanographic Institullon, Woods Hole, MA 02543. An equal opportunity employer M/F/H.

Lunar Curatorial Laboratory: Manager. Northrop Services, Inc. has operated and maintained the NASA Lunar Curatorial Laboratory at the Johnson Space Center, Houston, Texas since its inception. We are now searching for a manager candidate with a Ph.D. in geology or geochemistry, evidence of administrative skills and a record of publication in the study of lunar eamples and/or meteorite investigations. Position involves the supervision of 38 technical, scientific and deficial employees. Interested pergans about 45 course. ployees. Interested persons should send resume, including publications and references to W. B. Kurz. Manager of Personnel Services, Northrop Services, Inc., P.O. Box 34416, Houston, TX 77034. NSI is an equal opportunit

Research and Data Systems, Inc./Scientific Programmers and Programmer Analysts. Immediate openings for persons with B. tie oponings for persons with B.S. in science or math and at least two years experience with FORTRAN or PL1 on IBM systems. Work involves data processing and analysis from satellito based remote sensing systems. Experience with time sharing systems preferred. Also have openings for staff scientists with strong programming background. Send resume in confidence to Research and Data Systems, Inc., 9420 Annapolis Road, Lanham, MD 20801. Telephone: (301) 459-0001. Hydrogeologist. An outstanding career opportunity with excellent potential for advancement is currently open for a top professional interested in applied rosearch. Duties will include planning, deeigning and conducting broad-based groundwater resources investigations. Specialization in geochemistry including expertise derived from academic training or experience in hydrochemistry w be considered an asset. Demonstrated ability to plen and execute programs to study the evo of geochemistry processes in groundwater flow systems, including the movement of pollutants through granular or fractured rocks, is required Good writing ability is a must. District facilities include drill rig, sophisticated geophysical logging equipment, chemistry laboratory and in-house com puter and publishing facilities. Excellent fringe benefits package. Minimum solvance salary \$18,324 per annum depending on training and experience. Minimum qualifications include M.S. in hydrogeology or geochemistry or equivalent training and experience. Interested and qualified professionals are encouraged to apply to: Personnel, South Florida Water Management District, P.O. Box "V", West Palm Beach, FL 33402.

Equal opportunity employer.

Department of Earth Sciences, Marine Geophysics Research Post: University of Cambridge, U.K. University research post in Marine Geophysics involving teaching graduate students, planning and carrying out research at sea and some undergraduate lecturing. Silpend £8,615-£8,845 p.a., under review; live-year ap-pointment renowable Applications, curriculum vitae and names of three references to Dr. P. F. Friend, Department of Earth Sciences, Downing Street, Cambridge, CB2 3EO, England by 27th March.

Postdoctoral Fellowship in Experimental Petrology at UCLA. Starting approximately ptember 1, 1981, an up to 24-month appoint ment in phase equilibrium research, chiefly hydro-thermal synthesis, will be available. Candidates should possess Ph.D. Sand letter of application and arrange for two confidential recommendation to be forwarded to: W. G. Ernst, Earth and Space Sciences, University of California, Los Angales, California 90024.

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Vincent C. Kelley and Leon T. Silver **Graduate Fellowships**

THE UNIVERSITY OF NEW MEXICO

The Department of Geology of the University of New Mexico invites applications for the Vincent C. Kelley and Leon T. Silver Graduate Fellowships. The fellowships will be awarded on the basis of the scholastic record and academic promise of graduate applicants. Each fellowship will provide for a generous living stipend of \$1,000/month for 9 to 12 months, and up to \$2,000/year for travel and research expenses. The Caswell Silver Foundation will pay all tuition and university fees. The awards are made on an annual basis, but may be renewed for up to three years as long as the student maintains excellent academic standing and shows evidence of significant progress in research. Preference will be given to, but is not restricted to, applicants for the Ph.D. program.

An application for admission to the UNM Graduate Program, transcripts, Graduate Record Exam results (verbal, math & geology), three letters of reference and a brief statement of research goals are required for consideration for the fellowships. Application materials may be obtained

Rodney C. Ewing Department of Geology University of New Mexico Albuquerque, New Mexico 87131



The deadline for applications is April 1, 1981 for the Fall semester of 1981.

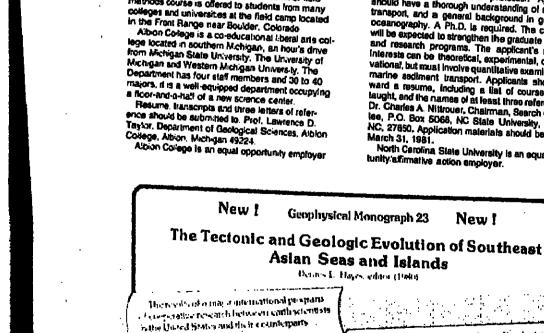
The Caswell Silver Distinguished Professorship in Geology THE UNIVERSITY OF NEW MEXICO

The Department of Geology of the University of New Mexico is pleased to invite nominations or applications for the Caswell Sliver Distinguished Professorship in Geology. This endowed professorship shall be awarded for periods of up to two years to earth scientists of distinguished accomplishment and international reputation. The professorship may be held by scientists of all specialities of the earth sciences in the broadest and the major called on the sciences in the broadest and the major called on the science in the the inthe broadest sense, and the major criterion for selection is that the in-dividual be an active, productive leader in his or har field of research. The recipient must carry out a vigorous research program while in residence at UNM. The recipient is expected to interact with the faculty and students of the Department and to provide one or more seminars, in an advanced topic of his/her choice, during each academic year. The Foundation will provide unusually advantageous remuneration commensurate with the distinguished nature of the appointment. In addition, a generous allocation for travel and operating expenses to include secrearial support, analytical services in department laboratories, use of field ehicles, and preparation of manuscripts) will be provided.

Applications or nominations should include a detailed resume and brief statement of major research accomplishments. Applications or nomina-tions should be forwarded to:

Rodney C. Ewing, Chairman Department of Geology iniversity of New Mexico Ibuquerque, New Mexico 87131

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Faculty Position Economic Geology

The Department of Geology, University of Georgia, has a tenure track opening in economic geology. Rank and compensation are open through the associate professor level.

Duties include (1) teaching courses in exploration geochemistry (2) supervising M.S. and Ph.D. candidates, and (3) developing a strong research program with significant field commitment.

Teaching and research interests in one or more additional fields such as ore deposit mineralogy, reliected light microscopy, theoretical geochemistry of ore deposits, fluid inclusion research, hydrogeochemistry, or environmental geochemistry are desirable.

An applicant should submit a detailed curriculum vitae and have at least three letters of recommendation sent to F. Donald Eckelmann, Head, Department of Geology, University of Georgia, Athens, Georgia 30602. The deadline for receipt of applications is May 1.

The University of Georgia is an equal employment opportunity/affirmative action institution.

Program Manager/Meteorology. Ocoanographic Services, Inc., is seeking qualified onplicants for the position of program manager for meleorological studies. Applicants should have an MS, or Ph.D. in mateorology or atmospheric sciences, plus experience in the field. A broad general knowledge of air pollution, and an un-destanding of the air pollution regulatory environ ment, is helpful interested persons should send resumo, references, and salary history to f1. C. Banks, Ocoanographic Services, Inc., 25 Gashhan Drive, Goldin, CA 93117.

Faculty Position: Petrology Tectonics. The Department of Goology at Siculord University has an opening for a full professor to work half-lime in the fields of potrology and tectonics. We seek someone who is interested both in teaching and in conducting research on the petrology and lectonics of commental margins. Applicants are invited to send letter of application, a resume and the names of three references by March 31, 1981 to-

School of Earth Sciences Stanford University As an equal opportunity and infirmative action employer. Stanford welcomen applications from women and minoritos

Upper Ocean Modeler. Two postdoctoral positions in upper-ocean modelling available in the mesoscale air-sea interaction group at the Florida State University, Ph.D. s with background in fluid dynamics, theoretical physical oceanography, dynamic moteorology, numerical analysis, or physics are invited to apply. Satary range \$19,000—\$21,500/year. Positions are supported by Office of Novel Executive Control of the Programme Control of the Naval Research and may be filled at any time after April 1, 1981. Send vitae and names of three references to Professor James OBrion, The Florida State University, Tallahassee, FL. 32306. The University is an equal opportunity employer

Sedimentology: University of Minnesota. The Department of Geology and Geophysics invites applications for a temporary faculty position in recent sediments starting September 1981. This is likely to become a tenure track assistant professor position starting fall 1982. Opportunities exist for interaction with the Limnological Research Cenfor and with active research programs in paleoecol ogy, paleomagnelism, hydrogeology, and low-tem-perature geochemistry, as well as with the St. An-thony Falls Hydraulic Laboratory. Ph.D. and strong Interest in research are required. Resume, statement of research interests, transcripts, and three letters of recommendation should be sent by March Dr. Anita L. Crews Sedimentology Search Committee Department of Geology and Geophysics 108 Pilisbury Hall Minneapolis, MN 55465

The University of Minnesota is an equal opportu-nity educator and employer and specifically invites and encourages applications from women and mi-

Structural Geologist/University of Califor-nia, Santa Barbara. Applications are invited for a tenure track appointment in structural geology to be filled during 1981-1982, subject to availability of perience, but preference will be given to the assistan ssor level. Successful candidates must have Ph.D. degree and strong dealire and commitment to teach and direct MA, Ph.D., and undergraduate students in both structural and field geology. He/she will be expected to develop a strong research program and obtain outside funding for its support. Additional duties may include leaching physical geology and

summer field geology. Please send resume and evidence of leaching and research proficiency, by March 31, 1981, and ar-range for early submission of four letters of recom-mendation to Dr. Arthur G. Sylvester, Chairman, Department of Geological Sciences, University of Call-fornia, Santa Barbara, CA 93106. (805) 961-3156. The University of California is an affirmative action/

Boise State University. The Department of Geology and Geophysics anticipates two tenure

Field-oriented Structural Geologist with eaching or research interest in one or more of teating or research interest in one or more or the following: economic geology, mineralogy, engineering geology, or geohydrology. Geophysicist specializing in applied seismology with a second area of interest in either geophysics

Ph.D. is required for both positions. Send resume. with at least three references to Monte D. Wilson, Chairman, Department of Geology and Geophysics, Boise State University, Boise, Idaho 83725. Bolse State University is an affirmative action/

Von Braun Post-Doctoral Fellowship in Space Physics/University of Alabama in Huntsville. Appointment effective September 1981 in a tenure track assistant professorship with reduced leaching load during the first two years. Re-search specially in estrophysics, planetary science or solar terrestrial physics. Research support available from UAH, NASA and Redstone Arsenal. Salary competitive. Recent Ph.D.s are invited to send resume, research plans and names of four references.

Apply to: Von Braun Fellowship Committee, Office of
Academic Affairs, University of Alabama in Hunts-

Equal opportunity in education and employment

Battelle, Pacific Northwest Laborate-ries. Applications are invited for a postdoctoral po-elton in geophysics with emphasis on middle or upper atmospheric research at the Battelle Observa-tory in Richland, Washington. Stipend will be \$18,000 initially; the position offers the possibility of a permanent research position at the end of the postdoctoral appointment. Address inquiries to R. A. Stokes, Battelle Observatory, Battelle, Pacific Northwest Laboratories, P.O. Box 999, Richland, WA 99352.

COURSES

Ground Water Modeling. Workshops in Ground Water Modeling are scheduled to be held this spring at the Holcomb Research Institute, But-ler University, Indianapolis, Indiana. The workshops feature the institute's international Clearinghot for Ground Water Models, which stores over 380 computer annotations of ground water models throughout the world. The workshops, co-sponsored by the National Water Well Association, range in complexity from basics in computer mode ng to adaptation of the Prickett/Lonnquist Model Dates for the 1981 workshops are as follows: Part I: An Introduction to Modeling Ground-Water Flow and Transport, May 27-29; Part II: Mathemat ical Foundations and Computer implementation of Ground Water Modeling, June 1-5; Part III: Analyt-ical Ground Water Modeling, May 18-22; Part IV: Adaptations of the Prickett/Lonnquiet Model, June

Instructors for Parts I and II are Drs. James Mercer and Charles Faust, GeoTrans, Inc., P.O. Box 2550, Reston, Va., 22090, Telephone (703) 435-4400. Instructors for Parts III and IV include Thomas A. Prickett, Special Consultant to Camp Dresser and McKee, Inc., and William Walton, Camp Dresser and McKee, 302 E. John St., Suite 1700, Champaign, II., 61820, Telephone (217) 384-4374.

For more information on course content, contact instructors. For more information on workshop accommodations, logistics, etc., contact Annabelle Paul or Richard Hyde, Holcomb Research Institute, Butler University, Indianapolis, In., 46208, Tele-phone (317) 283-9555 by April 30, 1981.

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Aeronomy Geochemistry

O460 Tides, waves and winds
CORRELATIVE STUDY OF THERMOSPHERIC
GRAVITY WAVES AND TROPOSPHERIC
VORTICITY AREA INDEX
Y. T. Chiu and L. R. Sharp (Space Sciences
Laboratory, The Aerospace Corporation, El
Segundo, Calif. 90245)
Based on the occurrence frequency of wavelike structures in 23, 691 individual measuremants of thermospheric density, we demonstrate
that there is no significant hemispherical correlation between satellite-measured thermospheric
wave-like structures and the tropospheric vorticity area index in the spoch 1972-1976. However, in the northern polar zone, (50°-90°) N,
wave occurrence frequency is greater for large
values of the 550 mb vorticity area index.
Geophys. Res. Latt., Paper 110217

1410 Chemistry of the remosphere
HE TMG-DIMENSIONAL DIAGNOSTIC PODEL FOR TROPOSPHERIC OM: AN UNCERTAINTY ANALYSIS
W. L. Chameides (Schoo) of Geophysical Sciences,
Georgia Institute of Technology, Atlanta, GA
100322 A. Tan
Tropospheric OM is believed to play a major
role in atmospheric photochemistry and, via its
chemical interactions, OM ultimataly may affect
tha climate, stratospheric ozone levels, and the
pH of rain. A valuable tool for predicting the
global OH abundance as a function of latitude and
altitude is the Du-dimensional diagnostic radel
for tropospheric OM. This model can also be
applied to budget studies of species which interact with OH, such as Dh, CO, and O₂. In addition to laboratory-obtained binetic data,
Important input parameters for the model are the
global distributions of H,O, O₃, NO, (NO * NO₃).
CO, and Ch., While the two-dimensional diagnostic model can be tuned to yield everaged absolute
OM concentrations in agreement with observations,
the results are highly sensitive to uncertaintles
in several important variables, including the
rase constants for key O(10) reactions, the rate
of haterogeneous removal of soluble species, and of heterogeneous removal of soluble species, and the global abundance and spatial variability in Mg.O.Q. (O. and NO. J. Geophys. Res., Green, Paper ICO165

Geodesy and Gravity

1910 Crustal movements
SEISHIC AND ABLISHIC DEFORMATION ASSOCIATED WITH
THE 1992 KERN COUNTY SARTHQUAFE, CALIFORNIA, AND
RELATIONSHIP TO THE QUATERRARY HISTORY OF THE
WHITE WOLF FAULT
R. Stein (U. S. Goological Survey, 143 Middlefield
Road, Henlo Park, CA 94025) W. Thatcher and R. O.
Castle

White Molf. yaur.

A. Stein (U. S. Geological Survey, 145 Middleffeld Road, Manlo Park, CA 94025) W. Thatcher and R. O. Castle

On 21 July 1952 rupture of the White Wolf fault produced the M. - 1.2 Rebrn County earthquake. We used the aftershock zone to delight the size of the faultand ally surface and applied monetrains imposed by the known 1952-55 horizontal charatrains to model the measured consists evertical displacements with an elastic dislocation model. A curved fault trace with degracing fault depth (27 to 10 km), slip (3 to 1 m), and dip (75 to 20) from the 1953 mpicenter at the southwest and of the fault toward the northeast provides the fit most consistent with the geodacic request, the measured seismic comment, the fault-plane solution, and the pattern of surface rupture.

Two short releveled linus near the 1952 spicenter tilted 4 and 17 wrad down to the north from 5-10 years before the surface rupture.

Two short releveled linus near the 1952 spicenter tilted 4 and 17 wrad down to the north from 5-10 years before the surface rupture. The short releveled linus near the 1952 spicenter tilted 4 and 17 wrad down to the north from 5-10 years before the surface repture. The short releveled linus near the case the received the passes of the linus. Leff-lateraf fault-crossing shear strain in the central fault from 0.2-20 years before the quake was two times greater than both presented 160 mm, macrompanied by any surface fault offset.

Baconstruction of the wertical separation on the Midts Wolf fault from lare Quaternary and late Midceme stratgraphic marker beds shows that the rate of 10-12 My. We estimate a 170- to 450-yr evarage recurrence interval for sarrhquakes on the Midts Wolf suit with slip equivalent to that in 1952. (Fre-seismid, post-seismid, geodetic, recurrence).

I. Geophys. Res., Red., Emper 6081831

Geophys. Res., Rad, Paper 8091831

1910 Crustal severents
THE IMPACT OF REFRACTION CORRECTION ON LEVELING
IMPACT OF REFRACTION CORRECTION ON LEVELING
IMPACTATIONS IN SOUTHERN CALIDORNIA
W. Strange (Rational Gendatic Survey, Rational
Comma Survey, Work, Reckville, Naryland 20857)
Recent investigations show that the cafraction
correction in leveling are large but can be
adequately modeled. The corrections are proportional to the responsive differences and the
square of the eight lengths. Changes in eight
length with time have resulted in apparant
crustal novements when non-refraction corrections
data were used. Applying refraction corrections
to investing data in southern California significountly alters the clus and configuration of the
southern California uplift. Uplift at Paindails
and Cormen-Labor relative to Los Angeles (TM VIZ)
during the 1953-1978 time period is no greater
than 10 cm. The bulk of the motion, about 6 cm,
occurs as localized motion along the San Gabrial
fault during the 1953-1954 time period. This
motion along the San Gabriel fault and uplift of
8 cm directly north of the San Fernande fault
between 1953 and 1965 may represent practurers to
the 1971 San Fernando sarthquaha.
J. Geophys. Res.. Red, Paper 8081492 ME IMPACT OF REFRACTION CORRECTION ON LEVELING

1910 Crustel Movements
AN INTERPRETATION OF EPISODIC SLIP ON THE
GRIATERAS FAULT MEAN SOLLISTER, CALLFORGIA
John O. Langbein, U.S. Geological Survey, 385;
Middlefield Road, Meolo Park, California, 94025;
Data from a precision Multi-Mavelength
Distance Hamsuring (MOMN) Instrustat, located
near Hollister, Galifornia, have been amalysed
in terms of strike-slap faulting in the region
oovered by the network. Four episodes of
deformation that are readily identifiable in the
MEMO data for the year following Saptamber 1975
oan be modeled as allp on the Calaprias Fault.
Orespector data tend to support this
interpretation since the orespectual of the
observed episodes of deformation appear, by he
observed episodes of deformation appear, by he
observed episodes of deformation appear, by

(Fault slip, linear programming, Geodette J. Geophys. REs., Red, Papar 180116 1950 Relations of gravity observations to LOSTAST, HACHA CHAMBERS AND PLATE DRIVIN, FORCES ON THE RAST PACIFIC RISE B. T. R. Lawis (Bept. of Oceanography and Geo-physics Program, Univ. of Vashington, Seattle, 98195)

physics Frogram, Univ. of Washington, Sastele, 98193)
The density distribution within a cooling plate is calculated which incorporates temperature and pressure iffeld within the plate and the gravity field at see level are captured for various degrees of isostatic compensation. In this model the pressure field within the plate and the gravity field at see level are captured for various degrees of isostatic compensation. In this model the pressure field within the plate has a horizontal gradient at shallow depths away from zero age and a horizontal gradient toward zero age at grater depths caused by the loading of the ocean. Isostatic equilibrium is approached if one allows the loading dot to the water to depress the seafloor and at the same time allows mass conservation by flow at depth toward zero age. A viscosity model hased on a Newtonian theology which included temperature and pressure offects has a high gradient close to the plane separating positive and negative pressure gradients which would facilitate the return flow and decouple the lithosphere from the sethenosphere. Addition of a trust to the homogeneous model does not substantially change these conclusions. Comparison of this model with examples of East Pacific Piac data suggests that some areas new not be in complete inestatic equilibrium, Emplying the existence of horizontal prossure gradients toward zero age in the asthenosphere.

This model can be made to fit the general features of the East Pacific Riso but not the detailed gravity and topography near zero age. If one allows convective cooling of the cruss by water, partial melting of the upper nantle and intrusion of this partial nois into the cruss, the water depths increase more rapidly near zero age and an increased positive gravity annoty is produced over the rise axis, both of which produce a better fit to Fast Pacific Rise may be associated with anomalous positive anomalies caused by a positive density contrast between mages and fractured porous crustal vocks.

(Isostany, ages chabber, c he density distribution within a cooling plate

the moment for each episode of slip can be determined from the MRH data by the technique of lines progressing. The results indicate that smalest slip is the dominant mechanism for atrain release since the combined moment of 1.16 x 1028 dyno-om for the four episodes fur acceeds the scenario of all of the centhumbus that communed during the year. Crospetter data

that occurred during the year. Creepaster data and geologic evidence that are taken in conjunction with the lower bound of the moment indicates that the depth of assissic slip for come of the spinodes of fault alip could extend to below the greatest depth of earthquake kypocenters for this region of central California.

Geomagnetism and Paleomagnetism

2540 Epatial variations attributed to sea floor spreading MAGNETIC EFFECTS OF MAGNETIFIZATION OF OCHANIC

ERUST K. Prévon (U.S. Geological Survey, MS 89, 145 Middlefield Road, Penio Park, California 94025; A. Lecallie and E. Mankinan Magnetic effects of maghemitimation are strongly dependent on the grain size of the originally unoxidized titen unequetite. Mag-hemitization of single-domain titenomegnetic ramits in a decrease in coercivity, an increase in susceptibility, and a large decrease in Q ratio. Meghemitization of multidomain titanomagnetic results in an increase in coercivity a decrease in susceptibility, and no large changes in Q ratio. The behavior of pseudomingla-domain titanomagnetics, which is the main catries of resuscence in submarine extrusive cocks, is investigated by comparing the magnetic properties of the FANOUS and the Lag 37 plilow basalts. The FANOUS rooks are already oxidized in 0.38), possibly as a result of mouse high-temperature magnetication of the magnet. Low-temperature magnetication of vanuits in a decrease in coercivity, an increase temperature maghemitization during cooling the magna. Low-temperature maghemitizatio such rooks does not result in appensiable changes of coardivity and susceptibility although the Q ratio does decrease and CRM assess to be acquired.

J. Geophys. Res., Red. Paper 180113

2560 Time variation, paleomagnetism PALEONAGRETISM AND AGE OF MAFIC PLUTONS, VECHITA MORNTAINS, OKLANDRA VORTAINS, CRIMENA

W. Roggenthen (South Dakuta School of Mines and Tachmology, Repid City, 5D 57701) J. Fischer, G. Hapoleose, and A. Fischer

A. Paleomagnetic reconnelsusages (43 samples of the Raggady Mountain Gabbre Group, comprised of a layered complex of morthosites, anorthosites gabbres, and massive gabbre, shown: (1) stable remanent asgestization and (2) consistent directions which differ significantly from those of the mearby Cambrian Wichite Granite Group, with exception of one site user the granite contact. These results suggest a Fracabrian age for the gabbre group. The difference in pole positions between the granitic and unfic groups demonstrates that the plutonic episodes responsible for the matic and granitic magnes are signifimain and silicic plutonism, (astacogen, Vichica Mountains, Procembrien, poleomagnetism).

Geophys. Ras. Lett., Paper 601,1401

2560 Time variations, palsomagnetiam
PALEOMAGNETISM AND TECTONIC EVOLUTION OF THE
PAR-APPICAN DAMARA BELT, SOUTHLESS AFRICA
H. H.CHILITUSS (Dupt. of Geophysics, Stanford
H. H.CHILITUSS (Dupt. of Geophysics, Stanford
University, Stanford, CA 3305) A. Frêmer
Paleomagnetic read the reported from the
Month, Cravi and Muldon Groups of the Damara
Supergroup, a late Processhriam shell sequence on
the southarn margin of the Congo trates in Hamibia. Three sepectisations were inclined in the
Month group samples. In order of decreasing
blocking temperature they are: Nyl (n=b sites,
1-28's, 0-133's, 0-13's, 0-26' (n=' nites,
1-28's, 0-133's, 0-13's). Overail precision of
all three sepectisations open Sectomic correction suggests that they predate Par-African (050450 Ma) folding. The segmetizations were twolated in the One's group samples, above the Month
is stratigraphic sequence. The DCI component of opasities pre-folding age (n=' sites, 1-52's',
0-186's, 0-193's') has been overprinted by the DC2
megnetization (n=10 sites, 1-52's', 0-048's, 14g13') of probable post-folding age. A single magisolated in the overlying Buiden Group samples
(n=6 sites, 1-12's', 0-000's, 3g-16'.
Together with previously published yaleomagnetic
data from African testonism in the Desawa belt
(McRihony and EMILITUSE, 196). Continental
cellision praceded by large relative displacements
and cigare of a vide ocean (n=a minulayan
nation) is vilentively ruled out for the Amery
with the waylable guinemagnetic and secont on the
which throube rifting, hearing, and stretching

of the lither-shore undernorth the Darata belt, tollowed by delamination of the sub-rustal lither-sphere. Not submouphorth entertal rises to take the place of the detached and mining litherand space of the detained and along ing little appoints being, inducting soldestion and interstanting of continental crant. The much thickened courting ontail crant to partially subted at depth, introded by symmond post-oroganic manufactures and finally uptified and enoded to its present level of exponent. The model to compatible with plate terionics in that the development of the flavour belt can be broadly consent with a state of the process. be the time development of the Harara bell broadly corpared with twicer rangingle seah, with the exception that stretching of the lithopshere was not induced by secondary convention above a downgoing wint. Possible causes for stratching are rinting matter plumps or intracontinental distortion within the pre-Damara African plate. platu. J. Graphys. Ros., Red, Paper 120079

2599 General or discellaneous
AMOMALOUS MACHETICATIONS IN 3.4 B.Y. OLD BARBARDOY
MOUNTAIN LAND SAMPLES
Stanley N. Ciscowski (MASA Headquarters, Si-1,
Washington, D.C. 20536)
The ratio of natural reconcess (NRM) to enturation reconcese (IRM) is found to be exceedingly
high for a misber of baselfic to ultramific samples from the 3.4 billion year old Hamberton
Mauntain Land greenations belt, South Africa,
Although conventional paleointenatic perhado indicate paleofields of several corateds, designed
tization curves plotted on logarithmic scale
clearly show the NRM in those sucples to be unlike thornal resumence (IRM). It weems may
probable that the observed MRK is a chemical rerphic event, and that the intense engagetizations
are perhaps the result of internality generated,
rather than external fields. The probability
that the intense engagetizations observed in these
ancient terrostrial supples in unrolated to the
strongth of the external field angaras cantion
in the interpretation of paleointensity results
from extrapersectival Externals. (Falcointensity,
Precambrian)

Hydrology

Goophya. Ros. Lott., Paper 80(177)

3123 Glaciology Tibal Plexure of Jakobshaves Glacies, West GREMLAND TIPAL PLENUR OF JAKURNANNS GLAGIER, MEST GRAEMLAND
Craig S. Lingle (Geophysical and Polar Research Center. University of Wisconsin, Madison, Maconsin, 33704). Terence J. Kughes (Department of Geological Sciences, University of Nains, Orono, Maine Géobl). Penaid C. Kollmeyer (Department of Physical Sciences, University of Const Guard Acadeay, New London, Connecticut (Dej20)
Jakobshavns Glacier, a Floating outlet glacier on the Vest Greenland coast, was surveyed during July 1974. The vertical displacements of targets along J profiles perpendicular to the flord wall bounding the north margin of the glacier were analyzed to determine the effect of flower caused by Italia oscillations within the (ford.)

of flavore caused by Ildal oscillations within the flord.

An analysis based on the assumption that vertical displacements of the glarter reflected pure electric bending vielded the conclusion that the effective thickness of the terific, the thickness which recaided unaffected by authors and bessi cracking and which behaved as a continuous was which a looks upglacter from the calving front, and will now to from the calving front,

the calving front, and willom who in free the calving front.
An analysis based on the more restistic assumption that observed benjing reflected elastic and viscoplastic deformation visided the conclusion that the average effective this mose of the ice was 100 2 km in word of the estimated 800 moral introduces: 2.0 bm fron the calving front, and 100 2 km from the calving front, and 100 2 km from the calving front. A constitutive relationship appropriate for hard glide during theorem was mied. (Tidal fleture, tidal bending, floating glacters.)

J. Couphys. Ros., Red. Paper 180110

Jillo Groundwater
FLOW IN ACCIFIERS WITH CLAY LANINAF-II ELACT
COLUTIONS
O.D. L. bereek IDepartment of Civil and Riveral Enginsering, University of Minnasona, USA)
Exact solutions are determined for two cases of
two-dimensional flow in aquifors with horizontal
lapareless luminas. The flow occurs in the vertical plans and the thickness of the laminas is
neglected. The first problem is one of configued
flow in an aquifor system with an infinite lamina
with a slot. The seasond one is a case of madonfixed flow is an equifor system with a semiinfinite limina. The solutions are determined by
the use of standard conformal mapping procedures,
and are ccapated with approximate solutions obtained by the use of the technique presented in
part i. The agreement is good, provided that the
factio of aquifor longth to aquifor thickness is
sufficiently large. (Exect solutions, conformal
mapping). wasping). Water Papour. Pes., Paper 80w1840

3150 Precloitation

3150 Precipitation
ACID RAIN: SOME PRELIMITARY RESULTS FROM GLORAL
DATA ANALYSIS
A. Sequeirs (National Oceanic and Atmospheric
Administration, Air Emsources Laboratories,
Silver Spring. Maryland 20910)
Praliminary results of an analysis of global
pracipitation data from WWO (World Nateorological
Organization) stations suggest that even remote
marietims baseline stations, far removed from
major continents, could become predisposed to
acid rain if there is a deficiency of non-marine
calcium relative to non-marine suiface. The
regional stations abov greater complexity than
the baseline stations in their pracipitation
chemistry. The overall results of this analysis
maggest that not all non-marine suiface and netrace in precipitation could be present as acid.
Geophys. Res. Lett., Repet 110011

Harder #1 DE Coultière à moder régles Victions

HAT PRINCIPLE STATE OF THE PRINCIPLE STATE OF Service of the servic CORN. PROCESS COMMENTS. The first of the control of the cont A set aller and the set of the se 10,000 The Paris of the second) Lie Spiret and and a summer or parent a layer and mercedial a day of manufacture parent of day of 1.40 and the second s I must not in anticept deals on our liberty of the second Secretary of the second second

Meetings

NOAA, NASA Plan Remote Sensing Series

A series of conferences on remote sensing has been scheduled by NASA and NOAA. Three of the NOAA conferences will immediately follow the NASA meetings at the identical locations.

The NASA conference at Purdue University will be a forum for university educators to discuss techniques, approaches, and curriculum materials for teaching remote sensing. The remaining NASA conferences will feature reports of data use from the Landsat Earth Resources Satellite. Applications of the data for natural resource and environmental management by state and local governments will be the focus.

At its conferences, NOAA will report on current and future activities for operational satellites designed for remote sensing of the land.

Registration for all NOAA conferences is being handled by Bill Span and Nancy Hooper, Metric, Inc., 290 Interstate North, Suite 116, Atlanta, Georgia 30339 (telephone: 404/ 955-1975). The dates and locations of the conferences and contacts for the NASA conferences follow.

March 9-11. Eastern Regional Remote Sensing Application Conference; Radisson-Ferncroft Conference Center, Danvers, Massachusetts; sponsor: NASA Goddard Space Flight Center; contact Lucretia Latta, Systems and Applied Science Corp., 6811 Kenllworth Avenue, Riverdale, Maryland 20840 (telephone: 800.638-0925).

March 12. Operational Land Remote Sensing Program, Boston Conference; Radisson-Ferncroft Conference Center, Danvers, Massachusetts; sponsor: NOAA.

March 23. Operational Land Remote Sensing Program, Southeastern Conference; Marriott Inte Allanta, Georgia; sponsor: NOAA. March 30-April 1. Western Regional Remote Sensing

Application Conference; Holiday Inn. Monterey, California; sponsor: NASA Ames Research Center; contact Gene Zaitsell, Bendix Field Engineering Corp., 155-A Moffett Park Drive. Sunnyvale, California 94086 (telephone: 415/965-

April 2. Operational Land Remote Sensing Program, Western Conference; Holiday Inn. Monterey, California; Eponsor: NOAA.

April 28-April 29. Operational Land Remote Sensing Program, Southwestern Conference: Sheraton Crest Hotel, Austin, Toxas; sponsors: NOAA and Texas Natural Resources Information System.

May 18-20. Conference on Remote Sensing Education '81 (CORSE '81); Purdue University, Lalayette, Indiana; sponsor: NASA Goddard Space Flight Center; contact; Shirley M. Davis, Laboratory for Application of Remote Sensing. Purdue University, 1220 Potter Drive, West La-fayetle, Indiana 47906 (telephone: 317/749-2052).

May 21. Operational Land Remote Sensing Program. Mid-Western Conference; Purdue University, Lefayette, Indiana; sponsor: NOAA. June 29 July 1. Landsat/Geobased Information System Symposium; Biloxi Hilton Hotel, Biloxi, Mississippi; sponsor: NASA National Space Technology Laboratories; contact Marjorie Smith, NSTL/Earth Resources Laboratory, NSTL Station, Biloxi, Mississippi 39529 (telephone: 601/688-3326). g

Abstract Deadline Extended

The deadline for abstracts of papers for the IASPEI General Assembly July 21-30 in London, Ontario (EOS, December 23, p. 1237) has been extended to March 27, according to the meeting's second circular.

The second notice outlines the meeting's scientific program, facilities available, registration, accommodations, transportation, and cultural and social activities. Convenors of the assembly also are listed.

Additional information and copies of the second notice can be obtained from A. E. Beck, Department of Geophysics, University of Western Ontario, London, Ontario N6A

Senior Position in Earth Science

The Earth Sciences' Division of the LAWRENCE BERKELEY LABORATORY has several comprehensive research programs involving the earth sciences. An opening exists for a person with an established national reputation in a scientific discipline in Earth Sciences, preferably geomechanics or hydrogeology, to assume a position of responsibility for the scientific leadership and direction of replantific me a position of responsively, major sadership and direction of major sadership as concerned with research programs such as concerned

Duties will include taking the scientific initiative and Duties will include taking the scientific initialive and direction and management of ongoing projects, including the nuclear waste isolation field involving more than 30 scientists and engineers at LBL and collaborative work with several academic and research organizations. Additionally, the position involves establishment of emerging programs, expansion of research facilities and pursuit of new areas of investigation.

The successful condidate should have extensive experience and proven capabilities in directing and achieving programmatic goals of complex restarch projects involving learns of senior scientists and engineers. A PhD in a field of the Earth Solences is preferred with significant conflictable extensions. preferred with significant applicable experisory; over \$50k.

Applications will be considered no later than April 1, 1981. Interested individuals should fewered two resumes including salary history to: Employment Office, LAWRENCE BERKELEY LABORATORY, One Cyclotron Drive, Berkeley, CA 94720. An equal opportunity employer Mif.





AGU CHAPMAN CONFERENCE Generation of the

Oceanic Lithosphere April 6-10, 1981 Airlie House, Warrenton, Virginia

Convenors: D. C. Presnall, A. L. Hales, and F. A. Frey

Sessions planned to date:

(1) Constitution of the crust and upper mantle at spreading centers

(2) Trace elements and isotopes Experimental petrology (4) Magmatic processes versus spreading rate,

metamorphism

(5) Magma chamber dynamics, melt migration, mantle flow (6) Tectonics of spreading centers (7) Hydrothermal activity, metasomatism,

Limited space remains. For information on registration and accommodations, write to AGU, Meet ings, 2000 Florida Avenue, N.W., Washington, D.C. 20009, or call Meetings, (202) 462-6903.

Exploration Geophysics

waves, turbulence). J. Gasphya. Res.. Green, Paper 100164

Geophys. Res. Lett., Paper 110217

0460 Tides, waves and winds winds and waves (10 min - 30 days) IN THE MESOSPEERS AND LOWER THERMOSPHERE AT SAEKATOM (32°M, 107°M), 1-4,3) DURING THE YEAR OCTOBER 1979 - JULY 1980 AND AND THE YEAR OF SPECE and Annual Territories of Species a

A.B. Manson (Institute of Space and Atmospheric Studies, University of Saskat-chawan, Saskatoon, Sask., Canada) C.E. Mack and J.B. Gragory Wieds (rom a medium frequency rader (2.2 MES), operating as a partial reflection drifts system, have been obtained for 4 seasons of 1987/80. Marmonic and spectral analyses have been used to

and spatiful analyses have been used to provide monthly profiles of sonal and seridonal winds, and the amplitudes and pheses of 12- and 24-h tides, at heights from 70-110 km. There are distinctive changes in tidal vertical wavelengths and phases between winter-like and sumper-like months. Pluctuations of the daily mean wind and tides during the stratwars of February 1980 are document-

ed,
Energy densities for oscillations
appropriate to waves ranging in scale
from gravity, through tidel, to planetsty waves are evaluated by month; they
are dempared with turbulence parameters
for energy dissipation rates and vartical
eddy diffusion coefficients. There are
making in winter and summer months, sugquating a relationship between some
waves and the Greation of turbulence.
(Mesospheric winds, tides, planetary
waves, turbulence).

0910 Saisale methods
ADDISTIC PROPRETIES OF MORTHERM ALASKA SHELVES
IM SELATION TO THE REGIONAL GEOLOGY
4. Fouts (Lesont-Deberty Geological Observatory
of Columbia University, Palisades, N.Y. 10964
5. Eltreis (U.S. Geological Survey, Hemlo Perk,
California 94023) A. Granca
Hora than 100 airgun-semobuoy records
from the northern Alaska shelves have been
reduced to yield an everse of 5 layers
from each record. Seafloor sound velocities,
regional velocity Cuncilous, and highcanolution velocity—death (news) from each record. Sensition sound valucities regional valucity functions, and high-record. Sensition valucities and high-recolution valucity-depth inversions were computed. Low sensition valucities in the borthwest of the colety-depth inversions were controlled to the colety-depth inversions were sensition of the Colety-depth inversion in the borthwest part of the otherwise Createcous seasiloot of the Colety-lie forcedesp represent thin lartisty sendings that overstep the Barrow arch from the north. Anticitian Cores of "aid-shelf erchas" [Grants at ul., in press] appear as 200 m/s velocity increases in the Meagens seasiloor of the value of the season season was a sensitive value of the coretal lope basin is indicated by low seasiloor sound velocities. The value of K in the lesse squares determination of the thickness that the seast from 1.74 km/s² around Fridhes Bay, to 1.33 km/s² mear the seast from 1.74 km/s² around Fridhes Bay, to 1.33 km/s² mear the Pourgeat part of the Brooktan sequence the Pourgeau part of the Brooktan sequence the purpose of the north Chukchi basin suggests. Createcous to Quaternary). A 2.1 km/s² value of Y in the Brooktan sequence they value of Y in the Brooktan sequence the part of the Brooktan sequence the part of the Brooktan sequence the part of the Brooktan sequence the value of Y in the Brooktan sequence the value of Y in the Brooktan sequence the value of the part Chukchi basin suggests calculated the part of the part of the sequence with the value of the part o

drounties). J. Geophys. Rap., Red, Paper BOBI616